Prepared for:
Cooperating Parties Group
Newark, New Jersey

LPRSA Human Health and Ecological Risk Assessment Streamlined 2009 Problem Formulation

Final

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Contents

List of Tables

List of Figures

Acronyms and Abbreviations

Acronym	Definition
AVS/SEM	acid volatile sulfides/simultaneously extracted metals
BERA	baseline ecological risk assessment
BOD	biological oxygen demand
BSAF	biota-sediment accumulation factor
CARP	Contamination Assessment and Reduction Project
CAS	creel/angler survey
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COD	chemical oxygen demand
COPC	chemical of potential concern
CPG	Cooperating Parties Group
CSM	conceptual site model
CSO	combined sewer overflow
DOC	dissolved organic carbon
ERA	ecological risk assessment
EMAP	Environmental Monitoring and Assessment Program
ESP	ecological sampling program
FFS	focused feasibility study
FSP	field sampling plan
FSP 2	Field Sampling Plan, Volume 2
HHRA	human health risk assessment
IBI	index of biotic integrity
LPR	Lower Passaic River
LPRRP	Lower Passaic River Restoration Project
LPRSA	Lower Passaic River Study Area
MPI	Malcolm Pirnie Inc.
NA	not applicable or not available
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NOAA	National Oceanic and Atmospheric Administration
NS&T	National Status and Trends (Program)
OMR	Office of Maritime Resources
PA	Partner Agencies
PAH	polycyclic aromatic hydrocarbon
PAR	pathways analysis report
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
PFD	problem formulation document

Acronym	Definition
POC	particulate organic carbon
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
REMAP	Regional Environmental Monitoring and Assessment Program
RI/FS	remedial investigation/feasibility study
RM	river mile
SDG	sample delivery group
SOP	standard operating procedure
SPI	sediment profile imaging
SPMD	semi-permeable membrane device
SQT	sediment quality triad
SS	suspended solids
SVOC	semivolatile organic compound
SWO	stormwater outfall
TBD	to be determined
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TOPS	trace organics platform sample
TPH	total petroleum hydrocarbons
TRV	toxicity reference value
TSS	total suspended solids
USACE	US Army Corps of Engineers
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
VOA	volatile organic analysis
VOC	volatile organic compound
VSS	volatile suspended solids

1 Introduction

The Lower Passaic River Restoration Project (LPRRP) Pathways Analysis Report (PAR), prepared by Battelle (2005), served to catalog the existing information for the purpose of planning the baseline risk assessment process for the Lower Passaic River Study Area (LPRSA). The Settlement Agreement (Section IX.37.d. (USEPA 2007a)) between the US Environmental Protection Agency (USEPA) and the Cooperating Parties Group (CPG) states: "Settling Parties shall conduct the baseline human health risk assessment and ecological risk assessment ("Risk Assessments"), in accordance with the Lower Passaic River Restoration Project Pathways Analysis Report…" The Settlement Agreement states that the PAR should be followed in conducting the risk assessments, although text within the PAR also acknowledges that additional planning will be required to develop a full work plan to complete the baseline risk assessments.

This streamlined problem formulation document (PFD) was developed to serve as the roadmap for initiating field and analytical work that will be used to complete the baseline risk assessments and to serve as the basis for a dialogue with USEPA and its Partner Agencies (PA), including: the US Army Corps of Engineers (USACE), the New Jersey Department of Environmental Protection (NJDEP), the New Jersey Department of Transportation (NJDOT), the National Oceanic and Atmospheric Administration (NOAA), and the US Fish and Wildlife Service (USFWS) on outstanding issues. A baseline risk assessment that incorporates as much site-specific data and information as possible is crucial for developing remedial goals that are site-specific and will support sound risk management decisions for the LPRSA.

This PFD is organized as follows. A description of the environmental history of the LPRSA is presented in Section 2. A compilation of existing data sources for sediment, biota, surface water and combined sewer overflow (CSO) water, and other key surveys and data sources is presented in Section 3. The framework for the human health risk assessment (HHRA) is presented in Section 4, with a description of the preliminary human health conceptual site model (CSM) and a summary of data needs for completing the baseline HHRA. The framework for the ecological risk assessment (ERA) is presented in Section 5, with a description of the preliminary ecological CSM, followed by the presentation of assessment endpoints, measurement endpoints, data use objectives, and data needs for completing the baseline ERA. The field sampling and analysis programs starting in 2009 are briefly described in Section 6; further details will be presented in specific quality assurance project plans (QAPPs) following consultation and agreement with USEPA and PA on the specific elements of the field programs.

The PAR presented a preliminary screening-level risk assessment using available data, non-site-specific data, and conservative assumptions to identify chemicals of potential concern (COPCs). The purpose of a second screening-level risk assessment would have been to further identify or refine COPCs for streamlining future field sampling and risk characterization. The CPG, USEPA, and PA agreed, at a meeting on December 3, 2008, that for field sampling to begin in 2009, a streamlined PFD would be appropriate. This approach keeps the analytical suite broad for the planned 2009 field work, thus eliminating the need for an updated screening-level risk assessment or a detailed quantitative summary of available data.[1] The 2009 QAPPs will provide sampling design details for 2009 sampling. Per agreement at the December 3, 2008, meeting, each QAPP will include a cover memorandum explaining the rationale for data collection and how the data collection effort is related to other data collection efforts and how they will ultimately support the risk assessments and risk management decisions for the LPRSA. Once a more comprehensive data collection effort is completed (i.e., after 2009), a final screening-level risk assessment

[1] The full suite of COPCs and media types identified in the PAR will be retained in the data collection programs planned for 2009 and 2010.

will be performed, consistent with USEPA guidance. A full review of the toxicological literature will be completed for prior to the screening-level risk assessment. In addition, the following technical memoranda will be developed to assist in planning for the baseline risk assessments:

- Data Usability Assessment and Data Evaluation Plan (including data use rules)
- Toxicity Reference Value (TRV) Development[2]
- COPC Selection Process
- Risk Analysis and Risk Characterization Plan (methods for exposure, effects, risk and ecosystem characterization, and uncertainty analysis for the ERA, and methods of exposure, dose-response assessment, risk characterization, and uncertainty analysis for the HHRA)
- Regional Urban Background Approach[3]

As information and data are collected, both the human health and ecological preliminary CSMs will be refined. Consistent with USEPA guidance, the risk assessment process is iterative, with each iteration and further refinement of the CSM influencing the risk analyses. Although it is impossible to eliminate uncertainty, each iteration will reduce the uncertainties in the risk assessments, which will inform risk management decisions in the LPRSA.

[2] Data quality levels were used to develop the 2009 QAPPs and are very conservative, generic analytical goals used solely for the purpose of evaluating laboratory analytical methods and achievable laboratory limits; these are not project-specific screening levels or preliminary remediation goals. These values will be developed in subsequent phases of the project.

[3] The approach for establishing regional background levels will be developed between USEPA/PA and CPG prior to the risk assessments, per the agreement of USEPA/PA and CPG during the March/April teleconference meetings. Consistent with the agreement, should USEPA/PA and CPG be unable to agree on an approach for establishing regional background levels, negative controls (i.e., lab-provided clean sediments) will be used as defaults.

2 Environmental History and Setting

The Lower Passaic River Study Area (LPRSA) has been highly modified to accommodate urbanization, including the development of residential areas and industrial activities. Figure 2-1 presents a map of the LPRSA. Changes in the Lower Passaic River (LPR) and watershed that accompanied European settlement and industrialization of the area to present day are well chronicled (Iannuzzi et al. 2002). Most of the tidal marsh, mudflats, shallow nearshore areas, and tidal wetlands historically present in the LPRSA have been either filled or dredged. Today, the majority of the shoreline in the LPRSA consists of riprap and sheet pile walls, resulting in a highly channelized river channel. Upper portions of the LPRSA feature generally steeper and less-modified shorelines with limited areas of riparian vegetation.

2.1 History of the LPR

More than 200 years of industrialization and urbanization have had a large impact on the LPR watershed, which was an important location for industry during the American Industrial Revolution (Malcolm Pirnie 2007b). Industrial operations included cotton mills, manufactured gas plants, paper manufacturers, chemical manufacturers, shoemakers, and recycling facilities (Malcolm Pirnie 2007b; Iannuzzi et al. 2002). These industries, as well as other industries that developed during the late 19th and early 20th centuries, used the LPR for process water and waste disposal, which adversely affected water and sediment quality (Iannuzzi and Ludwig 2004). The impacts to general water quality were reduced in 1970 when the Clean Water Act was passed (Iannuzzi and Ludwig 2004). However, overall sediment and water quality in the LPR are still impaired today as a result of historical and existing factors.

In 1858, the Dundee Dam and associated locks were constructed. After the completion of the dam, mills were built along the upper LPRSA near the city of Passaic (Iannuzzi et al. 2002). In the early 20th century, Newark, New Jersey, became one of the largest industrial cities in the United States. Industries included petroleum refineries, shipping facilities, tanneries, and various manufacturers (Battelle 2005). Above Dundee Dam, the city of Paterson was a significant center of industrialization and manufacturing beginning in the late 18th century.

Approximately 88% of the wetlands near the LPR and Newark Bay were lost after 1816 (Iannuzzi et al. 2002). Between 1873 and 1890, a large intertidal salt marsh along the south shore of the LPR was filled with material from coal gasification facilities (Iannuzzi and Ludwig 2004). Dredging in the LPR began in 1874 and continued until 1983, but little maintenance dredging occurred after 1940 (Iannuzzi and Ludwig 2004; Malcolm Pirnie 2007b). The dredging allowed for commercial shipping and for deeper-draft ships to dock in the lower section of the LPRSA.

Figure 2-1. Lower Passaic River Study Area

The LPRSA is an operable unit of the Diamond Alkali Superfund Site. In 1984, the Diamond Alkali Superfund Site was placed on the National Priorities List as a result of past industrial operations at the Diamond Alkali plant (80-120 Lister Avenue in Newark, New Jersey), which resulted in the release of hazardous substances such as polychlorinated dibenzo-*p*-dioxins (PCDDs) and pesticides. Sampling of Passaic River sediments conducted during the remedial investigation/feasibility study (RI/FS) for the Diamond Alkali plant revealed numerous organic and inorganic compounds including, but not limited to, PCDDs and polychlorinated dibenzofurans (PCDFs), pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and metals. In 1994, an investigation of a 6-mile stretch of the Passaic River centered on the Diamond Alkali plant was begun. Extensive sampling showed that the evaluation of a larger area was necessary because sediments contaminated with organic and inorganic substances and other potential sources of similar chemical compounds were present along at least the entire 17-mile tidal stretch of the Passaic River and were further dispersed by the tidal nature of the LPR. As a result, in 2001, USEPA expanded the scope of the Superfund study to encompass the 17-mile tidal stretch of the Passaic River and to add a large number of parties potentially responsible for historical releases that contributed to the chemicals found in the river. There are currently 73 companies represented in the Cooperating Parties Group (CPG) that entered into an agreement with the USEPA to fund this project.

Because of the long history of intensive human use and associated impacts, both chemical and physical degradation has occurred in the LPRSA. Today, multiple chemical stressors are present in the sediment, water, and biota as documented in the PAR (Battelle 2005). In addition, there are physical and biological stressors evident in the LPRSA that impact the nature of biological communities. The baseline risk assessments will be used to assess the current potential impacts from chemicals in the sediment, water, and biota from the river. The risk assessments will also be used to characterize the ecosystem impacts that may affect human and ecological populations. Chemical stressors will be evaluated to determine their potential impact to human and ecological receptors. Other contributing factors (i.e., biological and physical impacts) that may influence risks to the ecological and human populations using the LPRSA will also be discussed in the uncertainty analysis sections of the risk assessments.

2.2 Physical Setting of the LPRSA

The LPRSA can be characterized as a stratified estuary. The LPRSA receives inflows of marine (salt) water from Newark Bay and fresh water from the upper Passaic River (above Dundee Dam) and from the tributaries and the CSOs and stormwater outfalls (SWOs) located below Dundee Dam. The less dense fresh water flows downstream over the tidally influenced salt water that, on the flood tide, moves upstream from Newark Bay.

The current CSM (Malcolm Pirnie 2007a), has divided the LPRSA into three river sections. The salinity regimes associated with these river sections are based on Malcolm Pirnie (2005):

- Freshwater River Section (River Mile [RM] 10 to RM 17.4) is the region usually upstream of the salt front (based on initial model simulations conducted by Moffatt & Nichol (2009), the salt front appears to rarely extend further upstream than RM 13 and is upstream of RM 10 typically about 10% of the time).

- Transitional River Section (RM 6 to RM 10) is characterized by the most frequent location of the salt front, with water conditions varying from slightly brackish (or oligohaline, with salinity values ranging from 0.5 ‰ to 5 ‰) to moderately brackish (or mesohaline, with salinity values ranging from 5 ‰ to 18 ‰).

- Brackish River Section (RM 0 to RM 6) is located downstream of the typical location of the salt front, with almost always moderately brackish conditions (mesohaline, with salinity values ranging from 5 ‰ to 18 ‰).

The exact extent of the salt wedge (i.e., a wedge-shaped intrusion of salt water into the estuary that slopes downward in the upstream direction) is dependent on the tidal cycle and the volume of fresh water flowing downstream. In general, the saltwater wedge extends further upstream during spring flood tides and low river flow; the leading edge of the saltwater wedge is pushed further downstream during high-river-flow events. The exact extent of the salt wedge movement within the LPRSA is uncertain at this time because salinity data have not been routinely collected above RM 10, and that location was shown to have a maximum salinity between 3 ‰ and 6 ‰ during the summer of 2005 (Malcolm Pirnie 2007a). Additional water column monitoring for salinity, as well as for other physical and chemical characteristics, will be implemented as part of Field Sampling Plan (FSP), Volume 1, activities. The freshwater section of the river is dominated by freshwater benthic invertebrates and other freshwater species (Battelle 2005).The transitional and brackish sections of the river are dominated by estuarine organisms (Battelle 2005). Two sediment profile imaging reports of the LPRSA (Aqua Survey 2005; Germano & Associates 2005) illustrate differences in benthic invertebrate communities associated with salinity gradient. Germano & Associates (2005) found more Stage I invertebrates (i.e., initial community of tiny, densely populated polychaete assemblages at the surface and/or near surface) in the brackish river segments occurring either alone or in combination with Stage II invertebrates (i.e., transition community with some head-down deposit feeders) or Stage III invertebrates (i.e., the mature, equilibrium community of deep-dwelling, head-down deposit feeders). Much lower densities of solely Stage III invertebrates were observed in the brackish river section. In comparison, the freshwater section had a slightly higher proportion of Stage III invertebrates with high numbers of larger individuals compared to lower numbers of small, immature Stage I individuals. The exact demarcation between freshwater and estuarine organisms will be further refined as additional data are collected.

The LPRSA is relatively shallow, with maximum center-river depths ranging from a few feet (upper portions below Dundee Dam) to 30 feet near the mouth of the river. A federally authorized navigation channel exists between the mouth of the river and approximately RM 15.4 (USACE 2008). Sediment grain size in the main stem of the LPRSA below Dundee Dam gradually transitions from coarse material (gravel or rock), typically occurring in the upstream reach, to fine material (silts and fine sand), occurring near the mouth (Malcolm Pirnie et al. 2006). Some deviations from this trend are found in lower areas of the LPRSA where steepened shorelines have been armored, in erosional areas associated with bridge abutments, and near river bends.

As described above, the physical character of the LPRSA changes along the 17.4-mile stretch from the mouth of the river to Dundee Dam. The principal changes in the physical system along the 17.4-mile stretch include the salinity of the overlying water, quality of nearshore habitat, magnitude of tidal inundation, water depth, and sediment thickness and texture. The factors that most likely influence species distribution within the LPRSA (and thus potential exposure to chemicals) are salinity and sediment texture. More details on species distributions are provided in Section 5.

The river segments as defined based on the initial salinity data reported in Malcolm Pirnie (2005) were adopted for the preliminary HHRA and ERA CSMs (see Sections 4 and 5, respectively). However, the final CSM (including the boundaries of the transitional river section) for the LPRSA may change as additional data are collected from and compiled for the LPRSA. Additional data (e.g., salinity data, sediment chemistry data, sediment characteristics, shoreline and waterway characteristics, human use data) will also be used to determine the boundaries of individual river segments that will be assessed in the HHRA and ERA.

3 Data Summary

The lower 8 miles of the LPRSA have been extensively sampled from 1990 to the present through numerous investigation programs conducted by various agencies and organizations. Most of the data from these and other data collection events have been previously described (Battelle 2005, 2007a; Beck 2008; Malcolm Pirnie 2007b; Tierra Solutions 2003, 2004).

Tables 3-1 through 3-4 present relevant data collection events that occurred in and around the LPRSA for sediment, biota tissue, surface water, and CSO water, as well as other surveys. A data usability assessment has not been performed on all of the LPRSA data. Therefore, data collection events presented in the tables serve as a summary of data potentially relevant to the risk assessments. Relevant data available from previous data collection efforts will be used to supplement the data that will be collected for evaluation in the risk assessments. Preliminary summaries of environmental data needs for the baseline HHRA and ERA are provided in Sections 4 and 5, respectively.

Table 3-1. Summary of sediment data collection events for the LPRSA

Data Collection Event	Date of Collection	Number of Samples/ Locations[a]	Location (RM)	Depth (ft)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
Tierra Solutions, Inc. – Passaic 1990 Surficial Sediment Investigation	February 1990	4 stations, 4 samples	3.2 – 15.2	0 – 0.5	surface sediment	metals, PCBs, pesticides, SVOCs, PCDDs/PCDFs, cyanide	None	no validation
Tierra Solutions, Inc. – Passaic 1991 Core Sediment Investigation	November 1991	19 stations, 44 samples[b]	0.2 – 16.9	0 – 0.5	surface sediment	metals, PCBs, PCDDs/PCDFs, TPH, SVOCs, cyanide, organometals, pesticides, geochronology	partial	
NOAA – NS&T Hudson Raritan Phase I	March 1991	1 location, 2 samples	Harbor Reach	NA	surface sediment	metals, PAHs, PCBs, pesticides	none	no validation; no depth information available
Tierra Solutions, Inc. – Passaic 1992 Core Sediment Investigation	December 1992	5 locations, 10 samples[b]	1.1 – 15	0 – 0.3	surface sediment	metals, PCBs, pesticides, TPH, PCDDs/PCDFs, VOCs, SVOCs, cyanide, organotin, geochronology	partial	
NOAA – NS&T Hudson Raritan Phase II	January 1993	10 locations, 12 samples	0.8 – 8.7	0 – 0.1	surface sediment	metals, AVS/SEM metals, PCDDs/PCDFs, PAHs, PCBs, pesticides, AVS	none	no validation
Tierra Solutions, Inc. – Passaic 1993 Core Sediment Investigation-01	March 1993	7 locations, 9 samples[b]	1.1 – 6.9	0 – 0.25	surface sediment	metals, PCBs, pesticides, TPH, PCDDs/PCDFs, SVOCs, organometals, geochronology	none	no validation
Tierra Solutions, Inc. – Passaic 1993 Core Sediment Investigation-02	July 1993	10 locations, 19 samples[b]	0.6 – 6.9	0 – 0.25	surface sediment	metals, PCBs, pesticides, TPH, PCDDs/PCDFs, VOCs, SVOCs, organometals, geochronology	none	no validation

Data Collection Event	Date of Collection	Number of Samples/ Locations[a]	Location (RM)	Depth (ft)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
USEPA – REMAP	August 1993/1994	5 locations, 5 samples	0.2 – 4.7	0 – 0.1	surface sediment	metals, AVS/SEM metals, PAHs, pesticides, AVS, organometals, PCBs, PCDDs/PCDFs	full[c]	
Tierra Solutions, Inc. – Passaic 1994 Surficial Sediment Investigation	September 1994	22 locations, 22 samples	3.5 – 7.8	0 – 0.5	surface sediment/ sediment grab	metals, PCBs, pesticides, TPH, VOCs, SVOCs, PCDDs/PCDFs, cyanide	none	no validation
USACE – Passaic 1995 Minish Park Investigation	January 1995	2 locations, 4 samples	4.2	not specified	sediment core	metals, PCBs, pesticides, PCDDs/PCDFs, VOCs, SVOCs, TPH	none	no validation; data may be from below 0.5 ft (no depth specified)
Tierra Solutions, Inc. – 1995 Remedial Investigation Sampling Program	1995	100 locations, 211 samples[b]	1 – 6.7	0 – 0.5	sediment core	metals, PCBs, pesticides, TPH, PCDDs/PCDFs, SVOCs, herbicides, VOCs, cyanide, geochronology	full	
Tierra Solutions, Inc. – 1995 Sediment Grab Sampling Program	1995	7 locations, 7 samples[b]	2.5 – 2.7	0 – 0.5	sediment grab	PCDDs/PCDFs, cyanide	full	
Tierra Solutions, Inc. – Passaic 1997 Outfall Sampling Program	September 1997	3 locations, 3 samples[b]	1.2 – 5.7	0 – 0.5	surface sediment	PCBs, pesticides	none	no validation
NJDEP – 1998 – 2001 CARP Sampling Program	1998 to 2001	3	0 – 11	0 – 0.1	grab	PCDDs/PCDFs, grain size, metals, PAHs, PCBs, pesticides, wet chemistry	full and partial	limited data from LPRSA (RM 0 to RM 11); other data collected in New York/New Jersey area

Data Collection Event	Date of Collection	Number of Samples/ Locations[a]	Location (RM)	Depth (ft)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
National Coastal Assessment – Northeast/New Jersey Coast – USEPA EMAP	1998	1 location	1.9 – 2	0 – 0.1	surface sediment	metals, AVS/SEM metals, PAHs, pesticides, AVS, organometals, PCBs, PCDDs/PCDFs	full[c]	limited data from one location in LPRSA; other data collected in New York/New Jersey area
Tierra Solutions, Inc. – 1999 Remedial Investigation Ecological Sampling Plan (RI - ESP) Sediment Data	fall 1999	47 locations, 48 samples[b]	1 – 6.8	0 – 0.5	composite	AVS/SEM, cyanide, PCDDs/PCDFs, herbicides, inorganics, PCBs, pesticides, ammonia nitrogen, pH, organotins, grain size, SVOCs, PAHs, TOC, TPH, toxicity testing	full	limited to the RM 1 to RM 7 of the LPRSA
Tierra Solutions, Inc. – 1999 Sediment Sampling Program	1999	1 location, 3 samples	6.2	0 – 4.5	sediment core	metals, PCBs, pesticides, PCDDs/PCDFs, SVOCs, cyanide	quantitative QA/QC	limited in longitudinal extent; no samples collected in the surface (0-to-0.5-ft) interval
Tierra Solutions, Inc. – 1999/2000 Minish Park Monitoring Program	1999/2000	8 locations, 9 samples	5 – 5.1	0.5	composite	AVS/SEM, cyanide, PCDDs/PCDFs, herbicides, inorganics, PCBs, pesticides, ammonia nitrogen, pH, organotins, grain size, SVOCs, PAHs, TOC, TPH	quantitative QA/QC	limited in longitudinal extent
Tierra Solutions, Inc. – Spring 2000 RI – ESP Sediment Data	spring 2000	16 locations, 17 samples[b]	1 – 6.8	0.5	composite	AVS/SEM, PCDDs/PCDFs, herbicides, inorganics, PCBs, pesticides, ammonia nitrogen, pH, organotins, sulfide, grain size, SVOCs, PAHs, TOC, TPH	full	limited in longitudinal extent

Data Collection Event	Date of Collection	Number of Samples/ Locations[a]	Location (RM)	Depth (ft)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
National Coastal Assessment – Northeast/New Jersey Coast – USEPA EMAP	August 2000	2 locations	downstream of RM 11	NA	surface sediment	DDT, metals, PAHs, PCB and pesticides	full[c]	limited to one location in the LPRSA
National Coastal Assessment – Northeast/New Jersey Coast – USEPA EMAP	September 2002	2 locations	downstream of RM 6	NA	surface sediment	DDT, metals, PAHs, PCB and pesticides	full[c]	limited to two locations in the estuarine portion of LPRSA
MPI/Earth Tech – 2004 Sediment Coring for Dredging Pilot Project	July 2004	15 stations sampled; approx. 60 samples	2.6 – 3.1; cores from RM2.9	0 – 4	core	VOCs, SVOCs, pesticides, PCB Aroclors, PCB congeners, herbicides, PCDDs, metals, TOC, percent moisture, percent solids, Atterberg limits, specific gravity, and grain size	full except for PCB Aroclors, PCB congeners, herbicides, and PCDD (not validated)	chemical analyses were performed on only eight of the 3-to-4-ft samples of the 60 1-ft core segments collected
MPI – 2005 Geotechnical Sediment Cores	May 2005	51 stations sampled; 51 samples	0 – 16 (3 cores per transect every mile)	0 – 30.5	core	grain size (sieve and hydrometer analysis), Atterberg limits, bulk density, and TOC	NA	NA
MPI – 2005 Surface Sediment Grab Sampling Program	August/ September 2005	34 plus QC samples	1 – 17.4 plus Dundee Lake	0 – 0.08	grab	beryllium-7 and cesium-137 analyses to investigate potential high-resolution coring locations in order to help date sediment deposition	full	NA

Data Collection Event	Date of Collection	Number of Samples/ Locations[a]	Location (RM)	Depth (ft)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
MPI – 2005 High-Resolution Sediment Coring Program	September/ October 2005	14 stations sampled; approx. 560 samples, including QC samples	1.05 – 12.6 (for 5 cores with most analyses)	0 – 22.7	core	14 stations analyzed for radiological dating (cesium-137); select core segments from a subset of five stations also analyzed for TAL metals, PAHs, PCB congeners, PCDDs, and pesticides; approximately 516 samples analyzed for cesium-137; 228 samples analyzed for metals; 148 samples analyzed for PAHs; and 109 samples analyzed for PCB congeners and PCDDs	full and partial	schedule and budgetary constraints prevented several analyses; summary narrative available
MPI – 2006 Low-Resolution Sediment Coring Program	January 2006	10 stations sampled; approx. 54 samples	2.9 – 6.7	0 – 15.4	core	cesium-137, herbicides, TPH, TOC, geotechnical parameters, metals, PAHs, PCB congeners, PCB Aroclors, PCDDs, pesticides, VOCs, and SVOCs	full and partial	locations were co-located with 1995 Tierra Solutions, Inc., survey, but a direct comparison could not be made due to distance and core segmentation issues; summary narrative available

Data Collection Event	Date of Collection	Number of Samples/ Locations[a]	Location (RM)	Depth (ft)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
MPI – 2007 Dundee Lake High-Resolution Coring Program	January 2007	4 stations sampled; approx. 80 samples	Dundee Lake	0 – 3	core	radiological dating analysis, PCDDs, PCB congeners, PAHs, pesticides, geotechnical parameters, and TAL metals	full and partial	summary narrative available
MPI – 2007 – 2008 Supplemental Coring Program	December 2007 to January 2008	32 surface grabs and 20 cores (40 core samples)	1 – 12.6 and Dundee Lake (for surface grabs); 8.4 – 14.47 (for cores)	0 – 9	core and grabs	surface grabs analyzed for metals, TOC, grain size, and radiological parameters (surface grabs with confirmed beryllium-7 also analyzed for PCDDs, PCB congeners, PAHs, and pesticides); core samples analyzed for PCDDs, PAHs, pesticides, metals, TOC, PCB Aroclors, grain size, and radiological dating (12 core samples also analyzed for PCB congeners)	full and partial	summary narrative available
MPI – 2008 RM 0 to RM 1 Surface Sediment Sampling	June 2008	18 stations; 36 samples	0 – 1	0 – 0.5	grab	radiological parameters, TOC, TAL metals, PCDDs, PCB congeners, PAHs, pesticides, and grain size	full and partial	summary narrative available

Data Collection Event	Date of Collection	Number of Samples/ Locations[a]	Location (RM)	Depth (ft)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
CPG – 2008 Low-Resolution Coring Program	July to December 2008	109 stations sampled; approx. 700 samples	0 – 17.4[d]	0 – 30[e]	core and grabs	PCDDs/PCDFs, radiological dating, herbicides, pesticides, SVOCs, VOCs, metals, organotins, low-resolution mercury and methylmercury, PCB congeners, PCB Aroclors, grain size, TOC, cyanide, sulfide, TPH, PAHs, AVS/SEM, physical testing, nitrogen ammonia	full for first two SDGs for PCDDs and PCB homologues and congeners, then limited for other SDGs (not yet completed)	9 of the 118 locations were abandoned following SOP protocols, and sediment was not collected; dataset is not yet available

Note: Sources consulted to compile the information presented in the table include: Tierra Solutions (2003, 2004), Battelle (2005), Malcolm Pirnie (2007a, b), and site databases (e.g., ourpassaic.org).

[a] Numbers are approximate and may vary depending on how QA samples were counted.

[b] Additional samples were collected at depth, but the summary for this event refers to those samples collected in the upper 0.5 ft.

[c] Methods used to validate data collected in USEPA's Environmental Monitoring Assessment Program are available at http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/qaqc/93qaplan.html and http://www.epa.gov/emap/nca/html/docs/qaprojplan.html.

[d] Samples from above Dundee Dam, Third River, Saddle River, Second River, an unnamed tributary, and former Dundee Canal, including Weasel Brook, were also included in this sample count.

[e] Cores collected to refusal or parent material; maximum core length 30 ft. Grabs were collected to 0.5 ft.

AVS/SEM – acid volatile sulfides/simultaneously extracted metals
CARP – Contamination Assessment and Reduction Project
CPG – Cooperating Parties Group
EMAP – Environmental Monitoring and Assessment Program
ESP – ecological sampling program
LPRSA – Lower Passaic River Study Area
MPI – Malcolm Pirnie, Inc.
NA – not applicable or not available
NJDEP – New Jersey Department of Environmental Protection
NOAA – National Oceanic and Atmospheric Administration
NS&T – National Status and Trends (Program)
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
QA/QC – quality assurance/quality control
REMAP – Regional Environmental Monitoring and Assessment Program
RI – remedial investigation
RM –river mile
SDG – sample delivery group
SOP – standard operating procedure
SVOC – semivolatile organic compound
TAL – target analyte list
TOC – total organic carbon
TPH – total petroleum hydrocarbon
USACE – US Army Corps of Engineers
USEPA – US Environmental Protection Agency
VOA – volatile organic analysis
VOC – volatile organic compound

Table 3-2. Summary of biota tissue collection events for the LPRSA

Data Collection Event	Date of Collection	Number of Samples[a]	Location (RM)	Sample Type	Species Collected	Tissue Type per Species	Analyses	Level of Validation	Known Data Issues or Limitations
NJDEP – Toxics in Biota Monitoring Program	1986 to 2004	varied per event	approx. 0 and 16	fish, crab tissue	American eel	NA	PCBs, chlordane, DDTs, and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin	NA	limited to four species at limited locations in the LPRSA (Newark Bay [RM 0] and Monroe Street Bridge [RM 16])
					carp				
					striped bass				
					blue crab				
New York State Department of Environmental Conservation – PREmis database	1993	1	0.1	fish and inverte-brate tissue	blue crab	hepatopancreas and muscle	PCDDs/PCDFs, metals, PCBs, pesticides, and lipids	none	no validation; limited to blue crab, oyster, and three fish species (all fillet samples) at one location near the mouth of the LPR
					oyster	soft tissue			
					butterfish	fillet			
					scup	fillet			
					striped bass	fillet			
Tierra Solutions, Inc. – Passaic 1995 Biological Sampling Program	1995	13	1.1 – 4.5	fish and crab tissue	blue crab	edible muscle and hepatopancreas	PCDDs/PCDFs, metals, PAHs, PCBs, SVOCs, pesticides, organometals, cyanide, and TPH	full	limited to three species collected at locations in the estuarine zone of the LPRSA only
					mummichog	whole body			
					striped bass	fillet			

Data Collection Event	Date of Collection	Number of Samples[a]	Location (RM)	Sample Type	Species Collected	Tissue Type per Species	Analyses	Level of Validation	Known Data Issues or Limitations
Tierra Solutions, Inc. – RI – ESP Biota Sampling Program	October 1999	154	1.0 – 6.9	fish, crab, mussel tissue	adult striped bass	fillet – skin off	PCDDs/PCDFs, herbicides, metals, PAHs, PCBs, pesticides, SVOCs, organometals	full	limited to RM 1 to RM 7 of the LPRSA
						whole body			
					Atlantic menhaden	whole body			
					bluefish	fillet – skin off			
						whole body			
					crab	edible muscle			
						hepatopancreas			
						whole body – soft tissue			
					juvenile striped bass	whole body			
					mummichog	whole body			
					silverside	whole body			
					transplant ribbed mussel	whole body – soft tissue			
					white perch	whole body			
	May 2000	41	1.0 – 6.8	fish, crab tissue	adult striped bass	fillet – skin off	PCDDs/PCDFs, herbicides, metals, PAHs, PCBs, pesticides, SVOCs, organometals	full	limited to RM 1 to RM 7 of the LPRSA
						whole body			
					American eel	whole body			
					crab	edible muscle			
						whole body – soft tissue			
					mummichog	whole body			
					white perch	fillet – skin off			
						whole body			
	August 2001	13	6.0 – 6.9	fish tissue	American eel	fillet – skin on	PCDDs/PCDFs, herbicides, metals, PAHs, PCBs, pesticides, SVOCs, organometals	full	limited to RM 6.0 to RM 6.9 of the LPRSA
					brown bullhead	fillet – skin off			

Data Collection Event	Date of Collection	Number of Samples[a]	Location (RM)	Sample Type	Species Collected	Tissue Type per Species	Analyses	Level of Validation	Known Data Issues or Limitations
CARP – 2000 – 2004 Harbor Fish/Crustacean Collection	2000 – 2004	109	2.6	fish, crustacean tissue	American eel	whole body, without head/viscera	PCDDs/PCDFs, metals, PAHs, PCBs, pesticides	partial	limited to the lower portion of the LPRSA
					mummichog	whole body			
						whole body – homogenized			
					white perch	whole body, without head/viscera			
						whole body			
					blue crab	all edible tissue			
						hepatopancreas			
						muscle tissue			
					opossum shrimp	whole body			
						whole body – depurated			
					ribbed mussel	all soft parts			
					seven spine bay shrimp	whole body			
						whole body – depurated			
USEPA – EMAP and REMAP within the National Coastal Assessment – Northeast/New Jersey Coast	2000, 2002	2	NA	crab and lobster tissue; fish tissue	white perch and blue crab	whole	metals, DDTs, PCBs, and pesticides	full[b]	crab tissue chemistry data available at two stations in the LPRSA and one station in Newark Bay near the mouth of the river; limited to two species (white perch and blue crab) at two locations in the LPRSA

Note: Sources consulted to compile the information presented in the table include: USEPA EMAP and USEPA REMAP, Region 2, within the National Coastal Assessment – Northeast/New Jersey Coast, available online at http://www.epa.gov/emap/nca/html/about.html) (USEPA 2007b, c),Tierra Solutions (2003), CARP (http://www.carpweb.org/main.html), NJDEP(1990, 1993); Belton (1985), Horwitz (2005; 2006), NJDEP 2004 Routine Monitoring Program for Toxics in Fish: Year 2 – Estuarine and Marine Waters (http://www.state.nj.us/dep/dsr/2004data.htm); PREmis database (created January 21, 2006; available online at http://ourpassaic.org).

[a] Numbers are approximate and may vary depending on how QA samples were counted.

[b] Methods used to validate data collected in USEPA's Environmental Monitoring Assessment Program are available at http://www.epa.gov/emap/nca/html/docs/qaprojplan.html.

CARP – Contamination Assessment and Reduction Project
EMAP – Environmental Monitoring Assessment Program
ESP – ecological sampling program
LPR – Lower Passaic River
LPRSA – Lower Passaic River Study Area
NA – not applicable or not available
NJDEP – New Jersey Department of Environmental Protection
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
QA – quality assurance
REMAP – Regional Environmental Monitoring and Assessment Program
RI – remedial investigation
RM – river mile
SVOC – semivolatile organic compound
TPH – total petroleum hydrocarbons
USEPA – US Environmental Protection Agency

Table 3-3. Summary of surface water and CSO data collection events for the LPRSA

Data Collection Event	Date of Collection	Number of Samples[a]	Location (RM)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
Surface Water							
MPI – 2004 Hydrodynamic Survey (Mooring) Water Column Sampling	November 2004 and February 2005	3 locations; 26 samples plus QC	8.6, 10, and 11.5	grab	grab samples collected to supplement hydrodynamic data from moored instruments. Analyzed for POC, TDS, TOC, TSS, and VSS	full	NA
MPI – 2005 High-Flow Event Sampling	October 12, 2005	2 locations; 143 samples plus QC	Jackson St. and Ackerman Ave. Bridges	grab	one-day sampling event to evaluate solids transport during a major precipitation event; samples analyzed for TDS, TOC, TSS and VSS.	full	NA
MPI – 2005 Large-Volume Water Column Sampling	October 2005	1 location, 12 samples plus QC	2.5	large volume	PCB congeners, PCDDs, pesticides, TSS, DOC, and POC	partial	comparison study to evaluate TOPS, Infiltrex, and other large-volume sampling techniques; summary narrative available
MPI – 2005 SPMD Deployment	October/November 2005	4 locations; 8 samples plus QC	17; three tributaries[b]	composite	SPMD deployments intended to measure dissolved-phase organics; extracts analyzed for PCB congeners, PAHs, PCDDs, and pesticides	partial	NA

Data Collection Event	Date of Collection	Number of Samples[a]	Location (RM)	Sample Type	Analyses	Level of Validation	Known Data Issues or Limitations
MPI – 2005 Small-Volume Water Column Sampling	November 2005	8 locations; 267 samples plus QC	1, 2.5, 4.5, 10.5, 17 and three tributaries[b]	grab and composite	grabs analyzed for ammonia, BOD, herbicides, chlorophyll A, COD, cyanide, ortho-phosphorus and total phosphorus, TKN, TSS, SVOCs, and VOCs; composites analyzed for DOC, POC and metals	partial	summary narrative available
USGS – Surface Water Sampling for Environmental Dredging Pilot	December 2005	one location	Harrison Reach between 2.6 and 3.0	grab, Isco, TOPS, composite	TSS, POC, DOC, chloride/bromide, dissolved and total metals, PCDD/PCDF congeners, pesticides	NA	limited to the Harrison Reach area with one location in the LPRSA
CSOs							
Tierra Solutions, Inc. – 1997 CSO Sampling Program	September to November 1997	11	1, 3, 4, 5	grab	metals, organics, inorganics, pesticides, PCBs, herbicides, physical tests	unvalidated	
NJDEP – CARP CSO Sampling	2002 to 2004	35	4 locations	grab	PCDDs/PCDFs, metals, PAHs, PCBs, pesticides, wet chemistry	NA	
MPI – 2008 CSO/SWO & Tributary Storm Event Sampling	January 11, February 1, February 13, and March 8 (2008)	20 locations; 17 SWO, 13 CSO, 8 tributary, 10 sediment trap samples	8 SWO locations, 5 CSO locations, 3 tributaries,[b] 4 sediment traps	large-volume aqueous and sediment	PCDDs, PCB congeners, PAHs, pesticides, metals, TOC or POC, grain size, and radiological parameters	partial	summary narrative available

Note: Sources consulted to compile the information presented in the table include: Tierra Solutions (2003, 2004), Battelle (2005), Malcolm Pirnie (2007b), Malcolm Pirnie and EarthTech (2007); and site databases (e.g., ourpassaic.org).

[a] Numbers are approximate and may vary depending on how QA samples were counted.

[b] Reference to "three tributaries" consists of head-of-tide locations on Second River, Third River, and Saddle River.

BOD – biological oxygen demand
CARP – Contamination Assessment and Reduction Project
COD – chemical oxygen demand
CSO –combined sewer overflow
QC – quality control
RM – river mile
SPMD – semi-permeable membrane device
SS – suspended solids

DOC – dissolved organic carbon
MPI – Malcolm Pirnie, Inc.
NA – not applicable or not available
NJDEP – New Jersey Department of Environmental Protection
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
POC – particulate organic carbon
QA – quality assurance
SWO – stormwater outfall
SVOC – semivolatile organic compound
TDS – total dissolved solids
TKN – total Kjeldahl nitrogen
TOC – total organic carbon
TOPS – trace organics platform sampler
TSS – total suspended solids
USGS – US Geological Survey
VOC – volatile organic compound
VSS – volatile suspended solids

Table 3-4. Summary of biological community, habitat quality, bathymetry, hydrodynamic, and geophysical investigations conducted in the LPRSA

Data Collection Event	Dates of Collection	Location (RM)	Number/ Description of Sampling Locations	Description
Tierra Solutions, Inc. – Phase 1 Toxicity Identification Evaluation	July 2000	1 – 7	5	Investigated sediment toxicity to benthic invertebrates in the LPRSA. Conducted sediment and porewater toxicity tests using amphipod, *Ampelisca abdita.* Included in sediment quality triad assessment.
Tierra Solutions, Inc. – RI-ESP Benthic Invertebrate Community Survey	fall 1999, spring 2000	1 – 7	15 LPRSA, 3 reference area stations	Evaluated structure and composition of benthic invertebrate community in LPRSA, and compared to Mullica River (reference area). Included in sediment quality triad assessment.
Tierra Solutions, Inc. – RI-ESP Habitat Characterization Survey of LPRSA	fall 1999, spring 2000	1 – 7	continuous shoreline observations of both banks	Characterized shoreline habitats in LPRSA according to four categories: aquatic vegetation, bulkhead, riprap, and mixed vegetation. Included delineation of mudflats.
Tierra Solutions, Inc. – RI-ESP Fish Community Survey	1999/2000	1 – 6	15	Characterized LPRSA fish community during two events: late summer/early fall 1999 and spring 2000. Coordinated effort with fish tissue sampling program; community data were used to select target species for tissue collection. Qualitative pathology information was compiled on fish not collected for tissue chemistry analyses.
NJDEP – ambient biomonitoring network	1993,1998, and 2006	approx. 17 (at Dundee Dam), plus six stations on tributaries (e.g., Second, Third, and Saddle Rivers)	7	Taxonomic identification of benthic invertebrates was conducted.
NJDEP – Fish IBI Report: 2004 Sampling	summer and fall 2004	15.5	1	Fish community survey data was compiled.
USEPA – Fish Abundance Data for New Jersey	August 2000	9.9	2	USEPA coastal assessment program collected fish community survey data.
USEPA – EMAP within the National Coastal Assessment – Northeast/New Jersey Coast	1990, 1993	lower 6 miles of the Passaic River	1 location with 3 grabs collected	Conducted taxonomic identification and measured biomass of benthic invertebrates from numerous stations in Virginian Province.

Data Collection Event	Dates of Collection	Location (RM)	Number/ Description of Sampling Locations	Description
USEPA – EMAP within the National Coastal Assessment – Northeast/New Jersey Coast	2000, 2002	Between RM 5 and RM 11	1 location with 1 grab collected	Conducted taxonomic identification and measured biomass of benthic invertebrates from numerous stations along New Jersey coast. Benthic community data were limited to three stations in the LPRSA and one station in Newark Bay near the mouth of the river.
USEPA – REMAP, Region 2, within National Coastal Assessment	1998, 1999	NA	1 location	Conducted taxonomic identification and measured biomass of benthic invertebrates from numerous stations in Region 2. Benthic community data were limited to one station in LPRSA and one station in Newark Bay near the mouth of the river.
USACE – Flood Protection Feasibility: Main Stem Passaic River Volume III. Phase I	spring and summer 1981	mouth of Newark Bay up to the Dundee Dam, including the locations on the tributaries (Second, Third, and Saddle Rivers)	13	Data were from USACE fish community survey, which targeted only anadromous fish.
Princeton Aqua Science – Biocommunities Study	1981 and 1982	9	3	Data were from fish community survey, which targeted only one fish species (mummichog).
NOAA Northeast Fisheries Science Center – Benthic Macrofauna and Associated Hydrographic Observations Collected in Newark Bay, New Jersey	between June 1993 and March 1994	mouth of the Passaic River	2	Conducted taxonomic identification of benthic invertebrates from numerous stations in Newark Bay. Benthic community data were limited to two stations in Newark Bay near the mouth of the river.
Tierra Solutions, Inc. – RI-ESP Avian Community Survey,	1999 to 2000	1 – 7	4 survey areas	Surveyed LPRSA bird community during four seasonal events. Birds were identified by species, life stage, location, and counted.
Burger – 1999 Survey of Anglers (Newark Bay Complex),	1999	Newark Bay Complex	6 locations (1 near the mouth of LPR)	Anglers (267) were interviewed to assess consumption patterns and identify the reasons why people fish and/or crab, as discussed in Burger (2002).
Tierra Solutions, Inc. – Creel/Angler Survey (CAS)	2000/2001	1 – 7	Boat-based survey, 143 days; land-based survey, 101 days	Conducted boat-based counts and land-based interviews to provide data on the location and frequency of fishing. The land-based interviews provided more detailed data on a per-angler basis, including number of trips per year, the number of fish or crab caught and eaten, and general demographics.

Data Collection Event	Dates of Collection	Location (RM)	Number/ Description of Sampling Locations	Description
NJDEP – 1995 Urban Angler Survey (Newark Bay Complex)	1995	Newark Bay Complex	26 fishing and crabbing locations (2 in LPR)	Angler survey was performed to assess angler awareness and understanding of fish consumption advisories.
Tierra Solutions, Inc. – Single-beam Bathymetry Surveys,	1995, 1996, 1997, 1999, 2001	1 – 7	100-ft spacing of transects	Single-beam surveys were performed, with points taken every 2 ft. Surveys were conducted to characterize bathymetry and compare bathymetric data over time to assess sediment stability. Single-beam surveys were used for direct comparison at co-incident transects.
USACE – Single-beam bathymetry	2004	0 – 17.4	100-ft spacing of transects	Single-beam surveys were performed, with points taken every 10 ft.
USACE – Single-beam bathymetry survey	2007	0 – 8	100-ft spacing of transects	Single-beam surveys were performed on the navigation channel, with points taken every 10 ft. The survey covered only the navigation channel and transects stopped short of the river bank.
Rutgers – Hydrodynamic Survey July 2004-July 2005	July 2004 – July 2005	lower 6 miles of the Passaic River	varied by parameter	Measured river flow, sediment movement, and seasonal changes in salinity and temperature.
MPI – Hydrodynamic Survey	November 2004 to May 2005	upper 11 miles	3	Hydrodynamic data were collected as part of the LPRSA RI/FS. Work involved three buoys (moorings at RM 8.6, RM 10, and RM 11.5) deployed from November 2004 to October 2005. Data collected included surface and bottom salinity (conductivity) and suspended solids (TSS and VSS). Vertical velocity profile data collected during deployment are incomplete.
Tierra Solutions, Inc. – Hydrodynamic Studies	1995 – 1996	0.5 – 7.9	varied	Water-level fluctuations were documented at three tidal gages from April 1995 to June 1996. Velocity profile data were collected at eight cross sections from July 1995 to May 1996. Moored current meter data (including subset of temperature and salinity) were collected at three locations (from RM 1.4 to RM 6.8) from July 1995 to May 1996. Temperature, salinity (conductivity), and TSS data were collected from eight cross sections from July 1995 to May 1996.
Germano & Associates – Sediment Profile Imaging (SPI) survey of Sediment and Benthic Habitat Characteristics of the LPR	June 2005	0 – 16	134	Characterized the physical and biological conditions of surface sediments to assess the river's intertidal and subtidal benthic habitats. Sampling occurred along 27 transects, 4 to 5 sampling locations per transect, from Newark Bay to Garfield, New Jersey.

Data Collection Event	Dates of Collection	Location (RM)	Number/ Description of Sampling Locations	Description
Aqua Survey – Taxonomic Identification of Benthic Invertebrates from Sediment collected in the lower 17 miles of the LPR in support of the Lower Passaic Restoration Project	June/July 2005	0 – 16	28	benthic invertebrate fauna samples were collected at 28 sampling locations (25% of SPI survey locations) that were evenly distributed throughout the LPR. A subset of 100 organisms was subsampled from each sample, counted, and identified to the lowest practical taxon (family in most cases).
Tierra Solutions, Inc. – Ecological benchmarking assessment of LPRSA	2005	0 – 17	Continuous survey of 17 miles of LPRSA	Characterized and quantified the physical and ecological attributes, or "benchmarks," of LPRSA wetland and aquatic habitats for restoration planning purposes.
USACE – Vegetation Sampling, Wetland Delineation, and Bio-Benchmark Survey	2008	0 – 17, plus areas on tributaries and upstream of Dundee Dam	27	Conducted terrestrial vegetation surveys and wetland delineations at three locations and identified biobenchmarks in the LPRSA. Three reference areas (identified on the basis of wetland vegetation) were also identified within and outside of the.
CPG – Multi-beam Bathymetry	2007	0 – 14.3	NA	Survey obtained 100% coverage in navigable water.
CPG – Single-beam Bathymetry	2007	0.5 – 8.2 and 14.3 – 16.5	100-ft spacing of transects	Conducted single-beam survey of two designated areas along Passaic River. Points were taken every 0.5 ft. Survey was performed to duplicate the methods and equipment used during previous surveys of the river so that comparisons could be made between the previous surveys and the contractor's survey.
CPG – Multi-beam and Single-beam Bathymetry	2008	0 - 14	Multi-beam continuous; 13 transects (single-beam)	Conducted 2008 survey at same locations as those surveyed in 2007 in order to correlate 2007 data. Single-beam survey was conducted along 13 transects for a more direct comparison of pre-2007 data. Multi-beam survey included main channel and side slopes from RM 0 to ~RM 14.

Note: Sources consulted to compile the information presented in the table include: USACE (1987), NJDEP (1990, 1993), Belton et al. (1985), Horwitz (2005; 2006), Tierra Solutions (2003, 2004), Battelle (2005), Stehlik et al. (2005), Malcolm Pirnie (2007b), Aqua Survey (2005), Germano & Associates (2005), USEPA (2007b, c), Shisler et al. (2008), Burger (2002), and site databases (e.g., ourpassaic.org).

CAS – creel/angler survey
CPG – Cooperating Parties Group
EMAP – Environmental Monitoring and Assessment Program
ESP – ecological sampling program
FS –feasibility study
NOAA – National Oceanic and Atmospheric Administration
OMR – Office of Maritime Resources
REMAP – Regional Environmental Monitoring and Assessment Program
RI – remedial investigation
RM – river mile

IBI – index of biotic integrity
LPR – Lower Passaic River
LPRSA – Lower Passaic River Study Area
MPI – Malcolm Pirnie, Inc.
NA – not applicable or not available
NJDEP – New Jersey Department of Environmental Protection
NJDOT – New Jersey Department of Transportation
SPI – sediment profile imaging
SQT – sediment quality triad
TSS – total suspended solids
USACE – US Army Corps of Engineers
USEPA – US Environmental Protection Agency
VSS – volatile suspended solids

4 Human Health Risk Assessment

This section discusses the HHRA framework for the LPRSA. The preliminary human health CSM, including potential receptors and potential exposure pathways is presented and exposure areas are identified. In addition, based on the preliminary human health CSM, a preliminary summary of environmental data needs for the baseline HHRA is provided. Although the problem formulation step is formally part of USEPA's eight-step ERA process, and, as such, it does not typically address human health risk, it is included in the HHRA portion of the PFD in order to provide a comprehensive roadmap for implementing the 2009 fieldwork to support the baseline human health and ecological risk assessments for the LPRSA.

The preliminary human health CSM is presented in Section 4.1, followed by the preliminary discussion of environmental data needs for performing the HHRA in Section 4.2. The details of the sampling design will be provided in future comprehensive FSPs and associated QAPPs.

4.1 Preliminary Human Health Conceptual Site Model

A preliminary human health CSM that is more comprehensive than that presented in the PAR has been developed and will be further refined as data becomes available. The characteristics of the LPRSA vary considerably over its 17.4-mile length. As noted in Section 2, there are three zones defined by salinity (RM 0 to RM 6 is considered brackish; RM 6 to RM 10 is considered transitional; and RM 10 to RM 17.4 is usually considered fresh water). Based on preliminary reconnaissance along the LPRSA, there are major differences along the river's length in the characteristics that impact human use, including:

- Shoreline (e.g., sheet piling, bulkhead, riprap, docking, bridges, natural vegetation, mudflats)
- Land use and public access (e.g., industrial, commercial, highway, rail, park land, residential)
- Waterway use (e.g., large shipping, commercial craft, pleasure boating, and sculling or canoeing/kayaking)

As more information is collected throughout the RI/FS process, these and other factors will be considered to refine, as necessary, the boundaries of the three segments so that they are applicable and appropriate to the HHRA. Thus, the boundaries of the three river segments identified in this PFD, though adopted for the preliminary human health CSM, are preliminary and may change, pending the collection of additional site-specific data from the LPRSA. The preliminary human health CSM for the LPRSA is described below.

The physical setting of a study area, as well as its demography, surface features, and land use are important factors in forming the basis of a human health CSM. These factors are summarized below for the LPRSA. The LPRSA watershed is located south of the Dundee Dam and consists of over 100 square miles of a highly developed urban area located in portions of four counties in northeastern New Jersey (Passaic, Bergen, Essex, and Hudson Counties). These counties had a combined estimated population of 2.8 million people in 2006, with an average density of 4,700 people per square mile (US Census Bureau 2007). The city of Newark, with an estimated population of 280,400 in 2006 (US Census Bureau 2007), is located on the western bank of the LPR, near Newark Bay. Both the eastern and western banks of the river are dominated by numerous active and abandoned commercial and industrial properties. The banks of the river are highly developed and consist of miles of paved and bulkheaded shoreline. A few parks have been developed on fill placed in the flood plain along the eastern bank (Battelle 2005). Land use within the LPRSA is a mix of residential, commercial, and industrial uses. Intensive commercial and industrial uses occur along the lower reach of the river near Newark Bay as the result of a highly developed transportation infrastructure that includes highway, railway, and marine services. Urban uses,

including a highway, continue along the western side of the LPR as far north as RM 17.4. Land uses along the eastern shore above RM 6 include residential areas, parks, boat clubs, and some industrial areas.

The LPR has a long history of industrialization and urbanization. The current CSM (Malcolm Pirnie 2007a), supplemented by sampling conducted in 2007-2008 (see Tables 3-1 and 3-3), provides some detail on the legacy sediments in the LPR and conclude that they are an ongoing source of chemical contamination to the river. Additional characterization efforts, including a low-resolution coring program and water column sampling, will allow refinement of that assessment. Based on past and current activities in and adjacent to the river, there are a number of potential sources of chemicals, release mechanisms, and potentially affected environmental media. Some sources of chemicals are historical (e.g., industrial sources), although many are ongoing (e.g., CSOs and SWOs). Chemicals may have also leached from industrial point sources to groundwater, which may have discharged to the sediments and surface water of the river. The LPR is tidal, with water levels that rise and drop an average of 5.4 ft twice a day, periodically exposing shallow sediments and mudflats. Volatile organic compounds (VOCs) in surface water and exposed sediments may volatilize into the atmosphere. Bioaccumulative compounds in the river surface water and/or sediment may be taken up by aquatic organisms and subsequently consumed by humans.

Based on available information, the media of interest relevant to evaluating potential human health exposures for the LPR are:

- River surface water
- River sediment
- Mudflat sediment
- Fish tissue
- Shellfish tissue

As previously noted, outfalls serve as a continuing source of contaminants into the river sediments and surface water. Outfalls will be characterized during the RI/FS to understand their impact on the river and their contribution to risks. Therefore, direct contact with outfall effluent and sediment will be considered in the characterization of background risks. As described in Section 1, a regional urban background technical memorandum will be developed and will present an approach for incorporating background sources and risks, including CSOs, SWOs, upriver, tributaries and regional urban conditions, into the baseline risk assessments for the LPRSA.

The LPR is being used for limited recreational and other related activities. Several local boat clubs, and rowing associations, for example, are known to use the river for sculling. Land use along the lower 17.4 miles of the river varies considerably. The lower portion of the river is dominated by high-density commercial and industrial development, with limited public access to areas along the shoreline. The river is wider and deeper along the lower 6 miles; the lowest 1 mile is used predominantly for commercial activities (mostly fuel barges), and the remainder is used for commercial as well as some pleasure boating. The shoreline along the lower 6 miles is largely characterized by metal and wood bulkheading and riprap. In contrast, the upper reach of the river is characterized by more residential areas compared to other sections of the river, with several areas of access to the river. This segment of the river is narrower and shallower than the lower 6 miles, and recreational boat traffic is observed in this stretch of the river. A transitional zone consisting of a mixture of commercial, residential, and public park areas exists in the mid-section of the river.

NJDEP water classifications (i.e., primary and/or secondary contact recreation) for the various portions of the LPR were also identified. Waters of the lower portion of the river from the mouth to the confluence of the Second River (approximately RM 0 to RM 8) are classified as saline-estuarine 3 (SE3), which includes secondary contact recreation as a designated use (NJDEP 2008). Waters in the approximate region of RM

8 to RM 17 have a dual classification: freshwater 2 non-trout (FW2-NT), which includes primary and secondary contact recreation, for fresh water in that portion of the river; and saline-estuarine 2 (SE2), which includes secondary contact recreation, for saline water in that portion of the river (NJDEP 2008). Primary contact recreation consists of activities that involve a high potential for ingesting water (e.g., swimming), and the secondary contact recreation classification consists of activities during which there is a limited potential for ingesting water (e.g., boating). NJDEP has adopted, and USEPA has approved, water quality criteria for numerous toxic pollutants in the LPR.

Most of the LPR has been deepened as a result of various navigation projects. The current status of commercial navigation on the LPR has been described by USACE (2008). The document presents the authorized and constructed river depths and widths for the navigation channel in various segments of the river, and this information is included below in the descriptions of the Lower, Middle, and Upper River Segments.

It should be noted that the sale or consumption of fish and shellfish from the entire 17.4-mile LPRSA (from Newark Bay to Dundee Dam) is prohibited by the state of New Jersey (NJDEP and NJDHSS 2009) and has been since the 1980s. However, despite the presence of a fish advisory in the LPRSA, recreational fishing has been observed, and a small percentage of observed anglers report consuming their catch based on angler surveys conducted in the study area (Desvousges et al. 2001; NJDEP 1995). These surveys include a comprehensive year-long creel/angler survey (CAS) conducted by Tierra Solutions in 2000-2001 along the lower 7 miles (Finley et al. 2003; Kinnell et al. 2007; Ray et al. 2007a; 2007b; Desvousges et al. 2001); a 4-month survey of anglers/crabbers in the Newark Bay Complex conducted by NJDEP in 1995, which included two locations on LPR (NJDEP 1995); and a 4-month survey of anglers/crabbers conducted in the Newark Bay Complex in 1999, which included one location near the mouth of the LPR (Burger 2002). The Tierra Solutions CAS, which was conducted without USEPA's approval of the work plan, included boat-based observations, land-based counts, and angler interviews for 143 of 365 days (Desvousges et al. 2001). An independent expert panel provided review and oversight of the CAS (Finley et al. 2003). The methods, results, and data analyses were published in peer-reviewed literature (Finley et al. 2003; Kinnell et al. 2007; Ray et al. 2007a; 2007b). Statistical analyses of the survey data estimated the size of the fishing population to be 154 to 385 anglers and the size of the consuming population at approximately 37 individuals (Ray et al. 2007a).

Species reportedly caught and consumed by LPR anglers included white perch, catfish, striped bass, American eel, and carp (Desvousges et al. 2001; NJDEP 1995). Most anglers reported fillet as the type of tissue consumed; pan frying was the cooking method most reported (Desvousges et al. 2001; NJDEP 1995).

No anglers surveyed during the 2000-2001 CAS reported consuming crab (Desvousges et al. 2001). The 1995 NJDEP survey of anglers/crabbers of the Newark Bay Complex identified a single LPR angler reportedly consuming crab (NJDEP 1995). Between May and September 1999, researchers from Rutgers University interviewed 267 people angling at several locations within the Newark Bay Complex, including one location near the mouth of the LPR (Burger 2002). Of those interviewed, 110 people reported consuming only crab; 33 people reported consuming both fish and crab (Burger 2002). These surveys will be considered further in the evaluation of the potential fish and crab consumption pathways for the baseline HHRA. This evaluation will include a review of survey methodology, peer review, data reporting and analysis, key assumptions and uncertainties in results.

Because of the wide-ranging variability in land use along the LPR shoreline and the changing characteristics of the LPR itself, for the purpose of the HHRA it will be necessary to segment the river into specific areas relevant to characterizing potential human exposure under current and potential future use conditions. The results of the risk assessment for each segment will yield information relevant for determining remedial goals. Based on the preliminary human health CSM, the river has been separated into three segments that are defined based on areas of anticipated and/or observed land and waterway

use along the LPR. The segments of the river defined for the HHRA, denoted "Lower," "Middle," and "Upper" are described below. As noted above, the initial river mile boundaries of the three segments are based on salinity; however, the segment boundaries will be refined pending the collection of additional site-specific exposure data in the study area (e.g., shoreline and waterway characteristics, sediment characteristics, public access, human use). Although some of the same receptors and exposure pathways are anticipated to apply to all three river segments, it is expected that the level of exposure may differ among the receptor groups by river segment. Differences in exposure by the receptors in the different river segments will be reflected in the segment-specific exposure parameters ultimately identified for the HHRA. Child, adolescent, and adult age groups will be considered for each receptor, although exposure pathways may not be complete for certain combinations of age groups and activities and/or segments of the river. It should be noted that within each river segment, there may be specific areas of concern based on accessibility, desirability, human activity, as well as localized sources/chemical concentrations, which may need to be evaluated separately in the HHRA.

Last, it should be noted that the human health CSM is an evolving document, in that as new data and site-specific information are obtained, the human health CSM will be updated to reflect the current understanding.

4.1.1 Lower River Segment

The lower segment of the LPRSA (preliminarily defined as RM 0 to RM 6 based on salinity) is characterized as predominantly industrial/commercial in nature, with very little public access to the shoreline. The western/southern side of the river is characterized by high-density urban development (the city of Newark). The shoreline along this stretch of the river consists of active and abandoned industrial areas. The eastern side of the river consists of active or abandoned industrial properties and railway lines with recent and ongoing mixed-use development. Although there are some mudflat areas along both sides of this river segment, much of the shoreline contains bulkheads, and large areas are bordered by vertical sheet metal piling and/or railroad ties, making it difficult to access the river. Many areas of the riverbank sit above the river with vertical or steep access to the water. Swimming or wading along much of the lower 7 miles is limited by the characteristics of the shoreline, the commercial and industrial properties along the river, commercial boat traffic in the lower 1.7 miles, and limited public access; however, recreational boating (e.g., pleasure boating, kayaking, canoeing, sculling) is observed in this stretch of the river. Although it would be possible to fish from these areas, and some fishing was observed during the 2000-2001 CAS, extensive fishing along the lower 7 miles has not been observed. Evidence of homeless individuals has also been observed in this area.

The Lower River Segment is wide and relatively deep, particularly from the mouth of the river to RM 1, where the approximate average width is 1,386 ft, and the approximate maximum depth is 27 ft. The approximate average width and approximate maximum depth of the river in the remaining stretch of this segment are 513 ft and 25 ft, respectively. Based on the USACE 2008 commercial navigation analysis of the LPR (USACE 2008), the federal navigation channel in the Lower River Segment can be divided into three navigation sections based upon authorized depths (30 ft from RM 0 to RM 2.6, 20 ft from RM 2.6 to RM 4.1, and 16 ft from RM 4.1 to RM 6).

The lower 1.2 miles of the river can accommodate larger commercial vessel traffic, and the remainder of the Lower River Segment can accommodate modest-sized commercial vessels and recreational boats, as needed. Under USACE safe navigation guidance, the largest vessel that could safely pass the bridge at RM 1.2 would be, at a maximum, 48 ft beam. However, although the purpose of the USACE guidance is to ensure that new construction will be safe for the transit of a design vessel, it does not, in and of itself, prevent any vessel operator from taking any sized vessel up the river (USACE 2008). USACE survey information has shown that nearly all of the cargo in the commercial vessels that travel the LPR are loaded to a draft of less than 26 ft and that most of the firms receiving these shipments are located between RM 0 and RM 1.7 (USACE 2008).

Based on the characteristics of the Lower River Segment, the potential receptors to be evaluated, subject to confirmation as site-specific information is obtained, are:

- Current and future angler
- Current and future wader
- Current and future homeless person[4]
- Current and future boater
- Future swimmer
- Future resident

These receptors have the potential for exposure to chemicals in fish/shellfish tissue, river sediment and/or mudflat sediment, as well as those in river surface water via incidental ingestion and dermal contact, and/or inhalation of VOCs in outdoor air. The wader receptor is representative of several wading-like activities (e.g., a worker or someone picking up trash) and will be evaluated in a manner that is protective of the wide range of nearshore exposures that are associated with various potential wading activities at the LPRSA (i.e., risk will be calculated for the wading activity considered to have the most exposure).

A human exposure review proposed for LPRSA will document observations regarding the types of activities in which people are engaged along the river, including observations of homeless people. The angler, resident, and homeless receptors in this segment of the river may also be exposed to bioaccumulative chemicals through fish and/or shellfish consumption, although the potential for this pathway to be complete will be evaluated further. Because of the characteristics of the river and shoreline along the Lower River Segment, the potential for direct exposure to affected media for receptors in the Lower River Segment is expected to be limited and occur only on an occasional basis.

The potential receptor groups and potential exposure pathways described above are expected to be applicable for both current and future land use scenarios for the angler, wader, boater, and homeless person receptors. A future scenario, in which areas of the river may have been restored, would most likely result in greater exposure frequency than that of the current scenario; therefore, a future swimmer and a future resident receptor scenario will be evaluated. Future scenario evaluations will take changes in exposure into consideration.

4.1.2 Middle River Segment

The Middle River Segment (preliminarily defined as RM 6 to RM 10 based on salinity) is a transitional zone in terms of land use and is composed of a mixture of industrial, commercial, and residential areas and public parks. Much of the shoreline has limited access because of the presence of steep banks lined with sheet metal piling, railroad ties, and/or concrete, as described for the Lower River Segment. The Passaic River Rowing Association boat house is located at approximately RM 10. Access to the shoreline increases in sections of the Middle River Segment because of the presence of parks and residential areas,

[4] The characterization of potential exposures of and risks to the homeless receptor will be addressed in the uncertainty section of the risk assessment. In addition to potential exposures to river sediment and surface water, homeless people may be exposed to outfall effluent and sediment (i.e., from ongoing combined sewer, stormwater, and other permitted outfall discharges) via incidental ingestion and dermal contact based on the observed use of SWO water for bathing purposes by this receptor group. Bathing in SWO effluent by homeless individuals has been observed by project field staff on multiple occasions. Homeless people have also been observed near CSOs along the river; therefore, CSO, SWO, and other permitted outfall media are considered relevant potential exposures for the homeless person receptor. The potential for these exposure pathways to be complete will be evaluated further.

boat ramps, and other boating facilities, as well as exposed mudflat areas. The river in this segment is also narrower and shallower than in the Lower River Segment, with an approximate average width of 362 ft and an approximate maximum depth of 21 ft. The federal navigation channel in the Middle River Segment can be divided into two navigation sections based on authorized depths (16 ft from RM 6 to RM 8.1 and 10 ft from RM 8.1 to RM 10) (USACE 2008). The types of boats and extent of boat traffic in this stretch of the river are limited by the navigation depths. The Middle River Segment is more accessible for wading and/or swimming than is the Lower River Segment. These conditions are generally consistent with the NJDEP water-use classifications designated for this segment of the river (i.e., secondary recreational contact below RM 8 and primary and/or secondary, depending on salinity, above RM 8). The Middle River Segment is strictly depth- and width-limited to recreational boats.

Based on the characteristics of the Middle River Segment of the LPRSA, the potential receptors to be evaluated, subject to confirmation as site-specific information is obtained, are the:

- Current and future angler
- Current and future wader
- Current and future swimmer
- Current and future boater
- Current and future resident
- Current and future homeless person (see Footnote 4; this will be addressed in the uncertainty section)

All of these receptors have the potential for exposure to chemicals in river and/or mudflat sediment as well as river surface water via ingestion and dermal contact and/or inhalation of VOCs in outdoor air. The angler, resident, and homeless receptors in this segment of the river may also be exposed to bioaccumulative chemicals through fish and/or shellfish consumption. Based on characteristics of the river and shoreline in the Middle River Segment, the potential for direct exposure to affected media is expected to be somewhat higher than in the Lower River Segment.

The potential receptor groups and potential exposure pathways described above are expected to be applicable for both current and future land use scenarios. A future scenario, in which areas of the river may have been restored, would most likely result in greater exposure frequency than does the current scenario; however, the receptor groups and exposure pathways are expected to be the same. Any future scenario evaluation will take changes in exposure into consideration.

4.1.3 Upper River Segment

The Upper River Segment (preliminarily defined as RM 10 to the Dundee Dam) transitions, with increasing distance upriver, from a mixture of industrial, commercial, and some residential areas and public parks to more residential areas compared to other sections of the river. Pockets of residential areas directly abutting the river are situated along the Upper River Segment. Boat clubs, parks, and several small, private boat docks have also been observed in this segment of the river. The river becomes narrower, shallower, more residential, and less-densely populated in this segment, relative to the Lower and Middle River Segments. The approximate average width in this segment is 267 ft, and the approximate maximum depth is 14 ft. The authorized depth of the federal navigation channel throughout the Upper River Segment is 10 ft (USACE 2008). The Upper River Segment is strictly depth- and width-limited to recreational boats. There is residential access to the river as a result of the direct river frontage of some homes. The Dundee Dam is a barrier for the tidal movement of water and creates a manmade “head of tide.” Fishing has been observed at locations throughout the LPRSA, including near the Dundee Dam.

Based on the characteristics of the Upper River Segment, the potential receptors to be evaluated, subject to confirmation as site-specific information is obtained, are the same as in the Middle River Segment:

- Current and future angler
- Current and future wader
- Current and future swimmer
- Current and future boater
- Current and future resident
- Current and future homeless person (see Footnote 4; this will be addressed in the uncertainty section)

The potential for exposure to sediment and surface water in this segment of the river is anticipated to be greater than that in the other two segments because of the proximity of residential receptors and greater accessibility.

4.1.4 Summary of River Segments

Table 4-1 summarizes the potential receptors, potential exposure pathways, and exposure media associated with each segment of the river. Figure 4-1 presents a graphical representation of the current understanding of the human health CSM.

Table 4-1. Potential receptors, potential exposure pathways, and exposure media

Potential Receptor[a]	River Segment[b]	Potential Exposure Pathway	Medium
Current/future angler	Lower, Middle, and Upper	incidental ingestion, dermal contact, and/or inhalation of VOCs	mudflat sediment
		incidental ingestion and dermal contact	river sediment
		incidental ingestion, dermal contact, and/or inhalation of VOCs	river surface water
		fish consumption	fish tissue – fillet only
		shellfish consumption	crab – edible soft tissue
Current/future swimmer	Lower,[c] Middle, and Upper	incidental ingestion, dermal contact, and/or inhalation of VOCs	mudflat sediment
		incidental ingestion and dermal contact	river sediment
		incidental ingestion, dermal contact, and/or inhalation of VOCs	river surface water
Current/future wader	Lower, Middle, and Upper	incidental ingestion, dermal contact, and/or inhalation of VOCs	mudflat sediment
		incidental ingestion and dermal contact	river sediment
		incidental ingestion, dermal contact, and/or inhalation of VOCs	river surface water
Current/future boater	Lower, Middle, and Upper	incidental ingestion, dermal contact, and/or inhalation of VOCs	mudflat sediment
		incidental ingestion and dermal contact	river sediment
		incidental ingestion, dermal contact, and/or inhalation of VOCs	river surface water

Potential Receptor[a]	River Segment[b]	Potential Exposure Pathway	Medium
Current/future homeless person	Lower, Middle, and Upper	incidental ingestion, dermal contact, and/or inhalation of VOCs	mudflat sediment
		incidental ingestion and dermal contact	river sediment
		incidental ingestion, dermal contact, and/or inhalation of VOCs	river surface water
		fish consumption	fish tissue – fillet only
		shellfish consumption	crab – edible soft tissue
Current/future resident	Lower,[c] Middle, and Upper	incidental ingestion, dermal contact, and/or inhalation of VOCs	mudflat sediment
		incidental ingestion and dermal contact	river sediment
		incidental ingestion, dermal contact, and/or inhalation of VOCs	river surface water
		fish consumption	fish tissue – fillet only
		shellfish consumption	crab – edible soft tissue

Note: Potential receptors and potential exposure pathways may require updating pending further site reconnaissance and potential land use survey. The receptors and exposure pathways presented are anticipated to be the same for current and future scenarios, although exposure frequency may increase for a future scenario following restoration of area(s) along the river. The homeless receptor will be addressed qualitatively in the uncertainty section of the risk assessment.

[a] Adult, adolescent, and child age groups will be considered for each receptor, although exposure pathways may not be complete for certain combinations of age groups, activities, and/or segments of the river.

[b] River segment definitions: Lower = predominantly industrial and commercial with limited access; Middle = transitional zone of industrial, commercial, public park, and residential areas with public access; Upper = predominantly residential with some public parks and residential access.

[c] Future only.

HHRA – human health risk assessment

LPRSA – Lower Passaic River Study Area

VOC – volatile organic compound

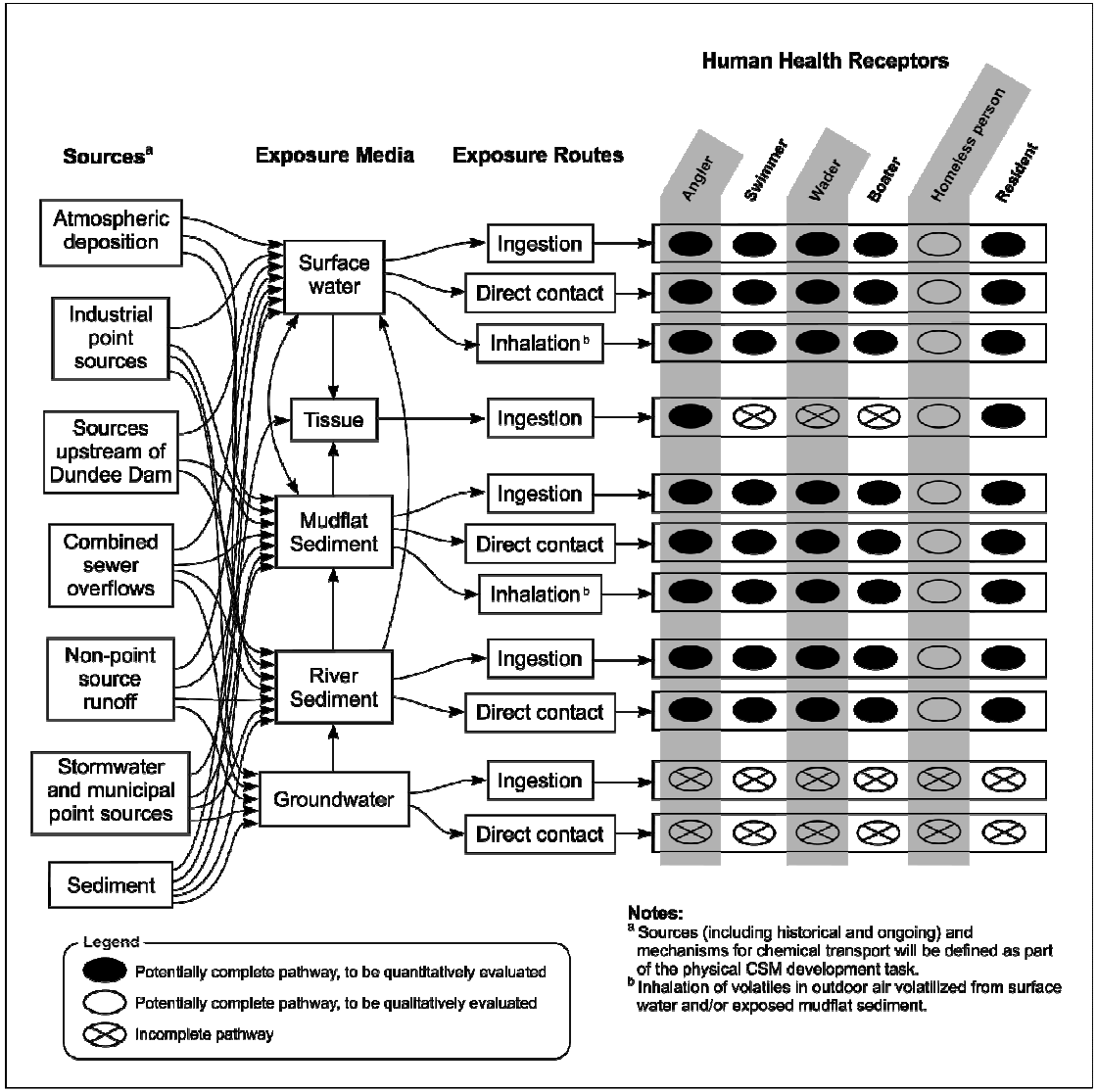

Figure 4-1. Preliminary Human Health Conceptual Site Model

4.2 Environmental Data Needs for Baseline HHRA

Based on the preliminary human heath CSM described above, Table 4-2 presents a preliminary summary of the environmental data that will be needed to estimate potential human exposures and assess potential adverse effects of river chemicals on human health. Specific data will be required for each medium of potential exposure and each segment of the river (Lower, Middle, and Upper). Table 4-2 identifies the environmental medium for which sampling data are anticipated to be needed, based on each potential receptor, exposure pathway, and river segment combination. As shown in Table 4-2, the following media with the potential for human exposure have been identified in the human health CSM:

- Mudflat/intertidal shoreline surface sediment (exposed sediment in the relatively flat, low-lying, intertidal areas between mean low tide and mean high tide)
- River surface sediment[5] (sediment under 2 ft or less of water between mean low tide and mean high tide)
- River surface water (in areas where swimming/wading is likely or has been observed and co-located with river surface sediment samples)
- Fish tissue (fillet only of targeted species from the following preliminary list: white perch, American eel, largemouth bass, channel catfish, brown bullhead, carp, striped bass)
- Blue crab (edible muscle only)
- Blue crab (edible soft tissue, which includes edible muscle and hepatopancreas)
- Blue crab (hepatopancreas only)

Table 4-2. Preliminary summary of environmental data needs for the human health risk assessment

Data Use Objective	River Segment[a]	Potential Receptor[b]	Potential Exposure Pathway	Medium
Estimate potential human exposure and assess potential adverse effects of river chemicals to human health via various potential exposure pathways	Lower, Middle, and Upper	current/future angler, wader, boater, swimmer, resident, and homeless person	incidental ingestion, dermal contact, and/or inhalation VOCs	mudflat sediment[c]
			incidental ingestion and dermal contact	river sediment[d]
			incidental ingestion, dermal contact, and/or inhalation VOCs	river surface water[e]
	Lower, Middle, and Upper	current/future angler, resident, and homeless person	fish consumption	fish tissue – fillet only[f]
			shellfish consumption	crab – edible muscle only[g]
			shellfish consumption	crab – edible soft tissue[g]
			shellfish consumption	crab – hepatopancreas only[g]

[5] Surface sediment defined as 0 to 0.5 feet.

Note: Potential receptors and potential exposure pathways may require updating pending further site reconnaissance and potential land use surveying. The receptors and exposure pathways presented are anticipated to be the same for current and future scenarios, although exposure frequency may increase for a future scenario involving restoration of area(s) along the river.

[a] River segment definitions: Lower = predominantly industrial and commercial with limited access; Middle = transitional zone of public parks and industrial, commercial, and residential areas with public access); Upper = predominantly residential with some public parks and residential access.

[b] Adult, adolescent, and child age groups will be considered for each receptor, although exposures may not be complete for certain combinations of age groups and activities, and/or segments of the river.

[c] Exposed mudflat sediment at mean low/high tide, in the relatively flat, low-lying intertidal area.

[d] River sediment under ≤ 2 ft of water at mean low/high tide.

[e] River surface water samples will be collected in the 0-to-6-ft swimming/wading zone and co-located with the river surface sediment sample locations.

[f] Fish species will be targeted from the following preliminary list: white perch, American eel, largemouth bass, channel catfish, brown bullhead, carp, striped bass.

[g] Crab tissue types will consist of blue crab edible muscle only, hepatopancreas tissue only, and blue crab edible soft tissue (muscle and hepatopancreas). Per USEPA request, the HHRA will evaluate the consumption of edible soft tissue (muscle and hepatopancreas), and a limited number of blue crab hepatopancreas-only and muscle-only samples will be collected for a comparison of tissue concentrations in the uncertainty section of the HHRA.

HHRA – human health risk assessment
USEPA – US Environmental Protection Agency
VOC – volatile organic compound

These environmental data needs are preliminary and subject to change as further information is obtained through the site investigation and data gathering process. These tasks include:

- Developing an understanding of chemical variability (particularly in the less-characterized upper reaches of the river)
- Identifying areas with unique exposures that may warrant expanded characterization

It should be noted that Table 4-2 does not address human exposure data on specific activities and site-specific characteristics of LPRSA receptors, such as would be gathered using site-specific surveys. Site-specific information is needed to characterize human activities and likely areas of exposure, particularly between RM 7 and RM 17. Based on site-specific information, certain exposure pathways may be identified as potentially complete but insignificant and not warrant quantitative evaluation in the baseline risk assessment. The process for obtaining site-specific human exposure data will be evaluated in concert with the agencies. Site-specific data collection events proposed for 2009 are described in Section 6.

It should also be noted that neither the PAR nor Table 4-2 addresses the background data that will be required to determine risk that is attributable to site conditions versus risk that is to the result of background conditions, including contributions from ongoing sources of contamination (e.g., CSOs, SWOs, and upriver and tributary sources). An approach for identifying appropriate background location(s), addressing data needs (e.g., characterizing CSO/SWO effluent and sediment), and for distinguishing site-related and background risks will be determined in concert with the agencies.

5 Ecological Risk Assessment

The PAR presented Step 1 (Screening-Level Problem Formulation and Ecological Effects Evaluation) and Step 2 (Screening-Level Exposure Estimate and Risk Calculation) of the eight-step USEPA ERA process. This section outlines the framework for Steps 3 and 4 of the eight-step process and serves as the roadmap for the baseline ecological risk assessment (BERA). In developing this Problem Formulation Document, several sources were evaluated, including the PAR (Battelle 2005), the 2006 BERA workshop meeting minutes (USEPA 2006), the focused feasibility study (FFS) (Battelle 2007b), USEPA's October 2008 response to comments to FSP, Volume 2 (FSP 2) (Yeh 2008), and the Tierra Solutions reports and documents from the 6-mile study area of the LPRSA (from RM 1 to RM 7) (the Tierra Solutions documents are listed in Section 3, Tables 3-1 through 3-4). This section also presents a summary of data needs. The details of the sampling design will be provided in future comprehensive QAPPs.

5.1 Preliminary Ecological Conceptual Site Model

The LPRSA is, for the most part, an industrial waterway and has been increasingly urbanized over more than two centuries, which has greatly decreased the functional and structural integrity of the ecological system. However, there are ecological receptors (e.g., invertebrates, fish, and wildlife) that live in, or otherwise use, the remaining habitats in the LPRSA. General ecological habitat areas have been identified in several habitat and vegetation surveys that have been conducted in the LPRSA within the past decade (Iannuzzi and Ludwig 2004; USACE et al. 2008). Based on the habitat survey conducted in fall 1999 and spring 2000, more than 80% of the lower 6 miles of the LPR shoreline consists of bulkhead or riprap, and less than 10% of shoreline contains aquatic/wetland vegetation (Iannuzzi and Ludwig 2004). Natural habitat areas along the shoreline, including wetland and mudflat habitats, are limited to small patches or isolated areas. Mudflats provide key foraging habitat for shorebirds, blue crabs, and fish that use the intertidal areas. Mudflats are more common in the estuarine portion of the LPRSA. Riparian vegetation in the LPRSA includes both native and non-native plant species; only 20 to 29% of herbaceous plant species and 60 to 80% of shrubs observed during the 2007 and 2008 vegetation survey were native species along the LPRSA (USACE et al. 2008). Wetland habitats are generally dominated by *Phragmites australis* (common reed) and *Spartina alterniflora* (smooth cordgrass).

Much of the shoreline in the lower portion of the LPRSA (below RM 6) is lined with concrete or sheet pile. However, three key small habitat complexes in the lower portion of the LPRSA have been identified: the area at the confluence of Lawyers Creek (approximate RM 0.5), a small marsh remnant downstream of the Worthington Avenue CSO (near RM 2.5), and a small, unnamed creek remnant and adjacent shoreline area near RM 3.5 (Iannuzzi and Ludwig 2004). Two intertidal estuarine wetland areas, classified by emergent, persistent vegetation, were also delineated in this lower portion during a 2007-2008 survey: one area was located between RM 3.9 and RM 4.5 (Harrison Wetland), and the other was at located RM 7.7 (Kearny Riverbank Park) (USACE et al. 2008). Further upstream, adjacent to the east bank of the upper, freshwater portion of the river, much of the land is designated as park land, with more vegetation (i.e., shrubs and herbaceous plants) (USACE et al. 2008). One intertidal wetland area was delineated in this upper freshwater section of the LPRSA at RM 10.9 (Riverside County Park) (USACE et al. 2008).

The long history of industrial activities along the LPRSA has impacted the benthic invertebrate, fish, and bird community structures. The benthic community of the LPRSA is primarily made up of pollution-tolerant organisms (Iannuzzi and Ludwig 2004). Blue crabs are reported to be found throughout the LPRSA. During a 1999 and 2000 survey, 22 fish species were collected, and 49 bird species were observed (Iannuzzi and Ludwig 2004). Mummichog was the most commonly collected fish species; other common fish species collected included inland silverside, white perch, Atlantic menhaden, striped bass, and gizzard shad. Gulls, ducks, and swallows were the dominant bird species present. Sediment-

probing shorebirds use mudflat habitats along the LPRSA, and piscivorous birds (e.g., herons and egrets) have also been seasonally observed along the LPRSA.

The general preliminary ecological CSM (Figure 5-1) presents the current understanding of the potential exposure routes and pathways from affected media to ecological receptors. The general preliminary ecological CSM has been broken down into two specialized ecological CSMs for estuarine and freshwater receptors. Salinity acts as a barrier to species movement for most ecological species, with the exposure of these species limited to areas within specific salinity ranges. A number of fish and invertebrate species found in the LPRSA are expected to be intolerant of significant changes in water salinity, especially freshwater species, although some estuarine species are also intolerant of extended exposure to fresh water. Some marine and estuarine species are expected to be limited to areas of the river characterized by brackish or higher salinity transitional conditions. Likewise, true freshwater species are expected to be limited in their downstream movement by salinities characteristic of freshwater conditions. The CSMs identified for estuarine and freshwater receptors are based on the three river sections defined by the initial salinity reported by Malcolm Pirnie (2005) and presented in Section 2.2. The estuarine portion of the CSM is represented by the brackish (RM 0 to RM 6) and transitional (RM 6 to RM 10) river segments, and the freshwater portion of the CSM is represented by the freshwater (RM 10 to RM 17.4) river segment. As previously stated, information gathered as part of future sampling events, and through the additional evaluation of site-specific data, will be used to update these preliminary ecological CSMs, as necessary. Additional data (e.g., salinity data, sediment chemistry data, sediment characteristics, shoreline and waterway characteristics, human use) will also be used to determine the boundaries of individual river segments that will assessed in the HHRA and ERA. If additional site-specific data identify wetlands that connect to the LPRSA, wetland soils will be sampled within the LPR for evaluation in the ERA.

The preliminary ecological CSMs for the identified estuarine and freshwater receptors are presented in Figures 5-2 and 5-3, respectively. Figure 5-2 represents the preliminary CSM for the brackish (RM 0 to RM 6) and transitional (RM6 to RM 10) river segments. Figure 5-3 represents the preliminary CSM for the freshwater (RM 10 to RM 17.4) river segment. The ecological receptors in the estuarine and freshwater sections of the LPRSA are divided into four major receptor groups: benthic invertebrates, fish, birds, and mammals. Ecological receptors from each of these receptor groups were selected for both the estuarine and freshwater ecological CSMs, and potential exposure pathways of chemicals to these receptors were identified. Selected ecological receptors and potential exposure pathways are illustrated in the ecological CSM figures and are discussed in the following sections.

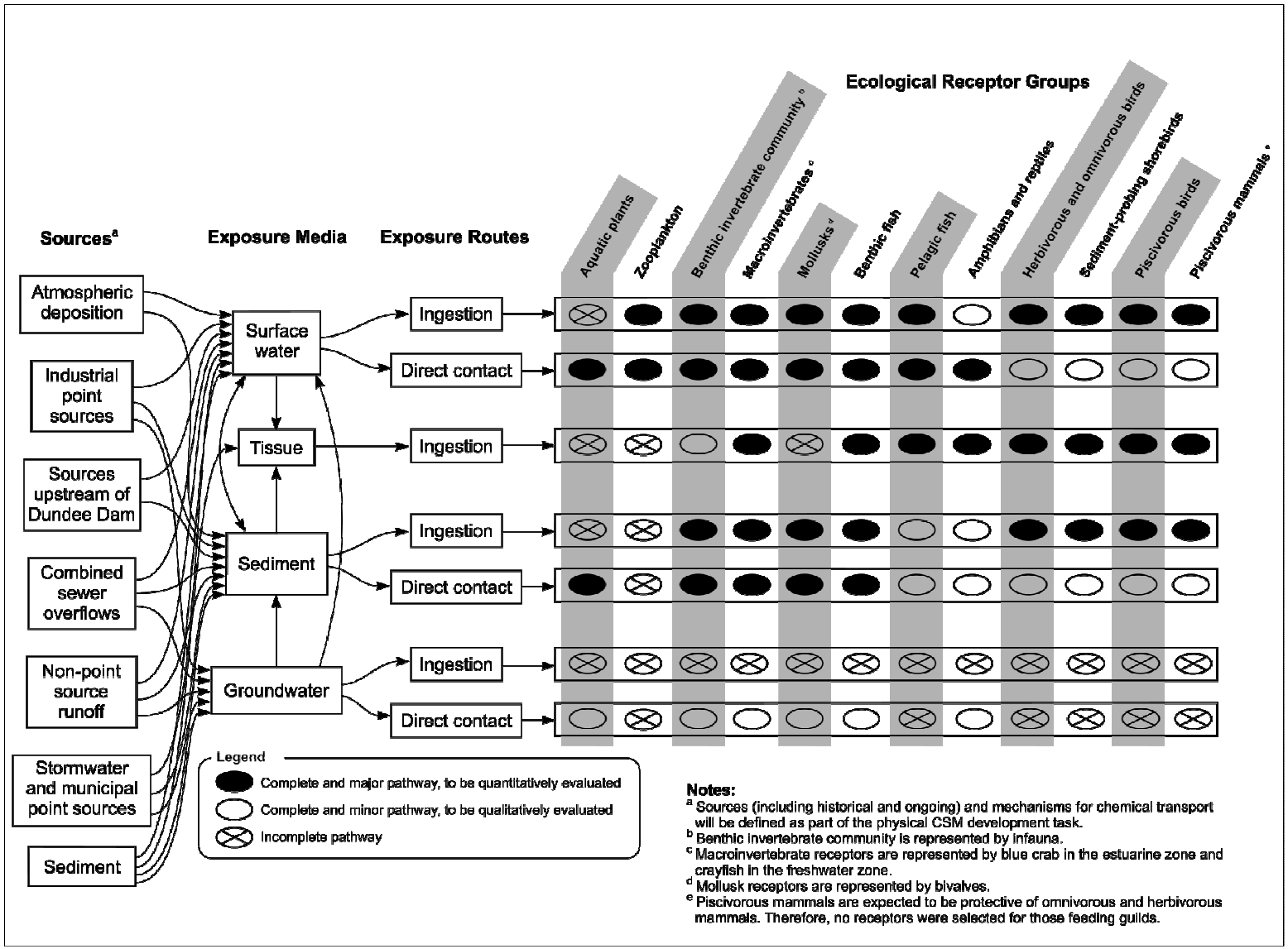

Figure 5-1. General Ecological CSM for LPRSA

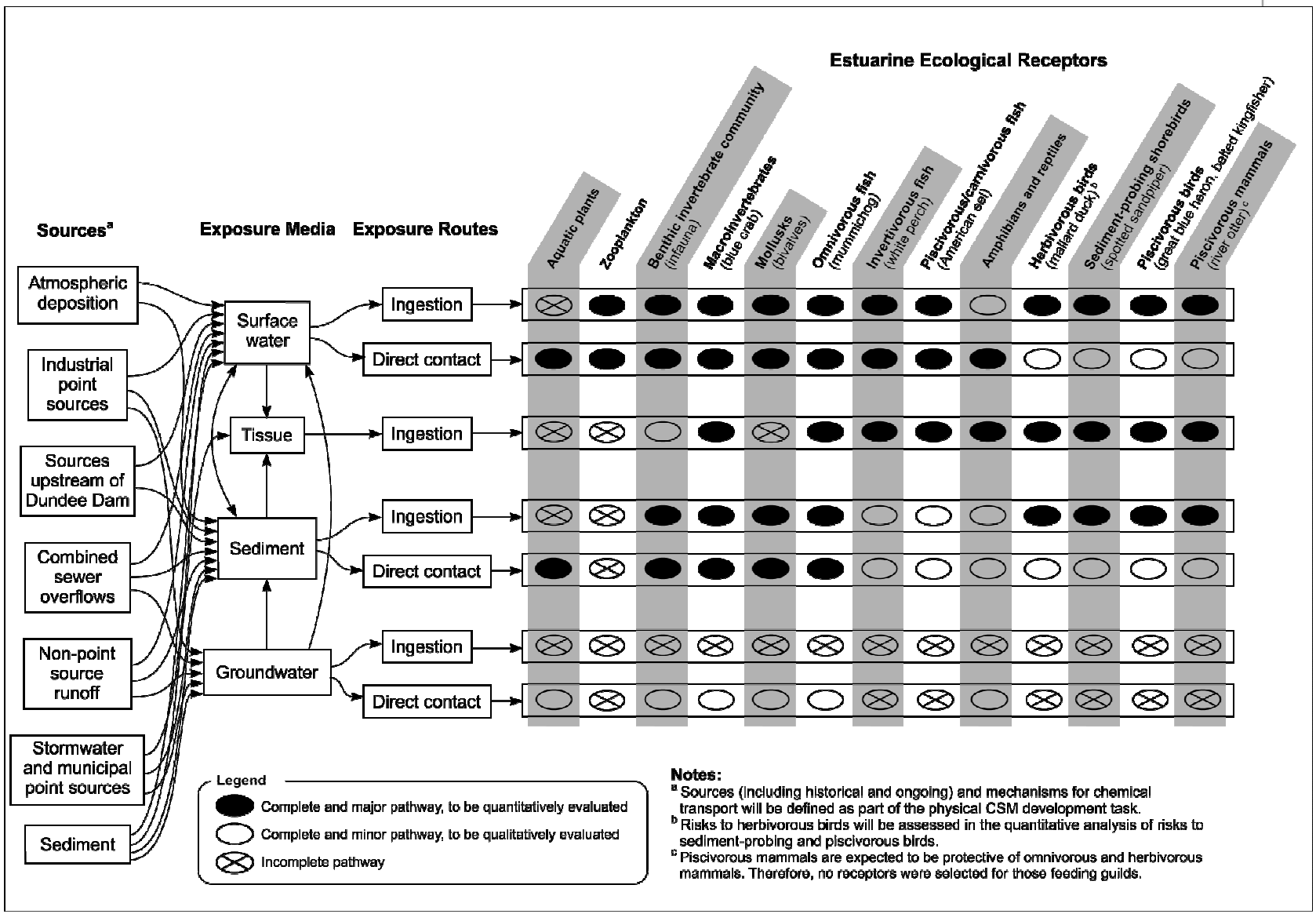

Figure 5-2. Preliminary ecological CSM for LPRSA estuarine receptors

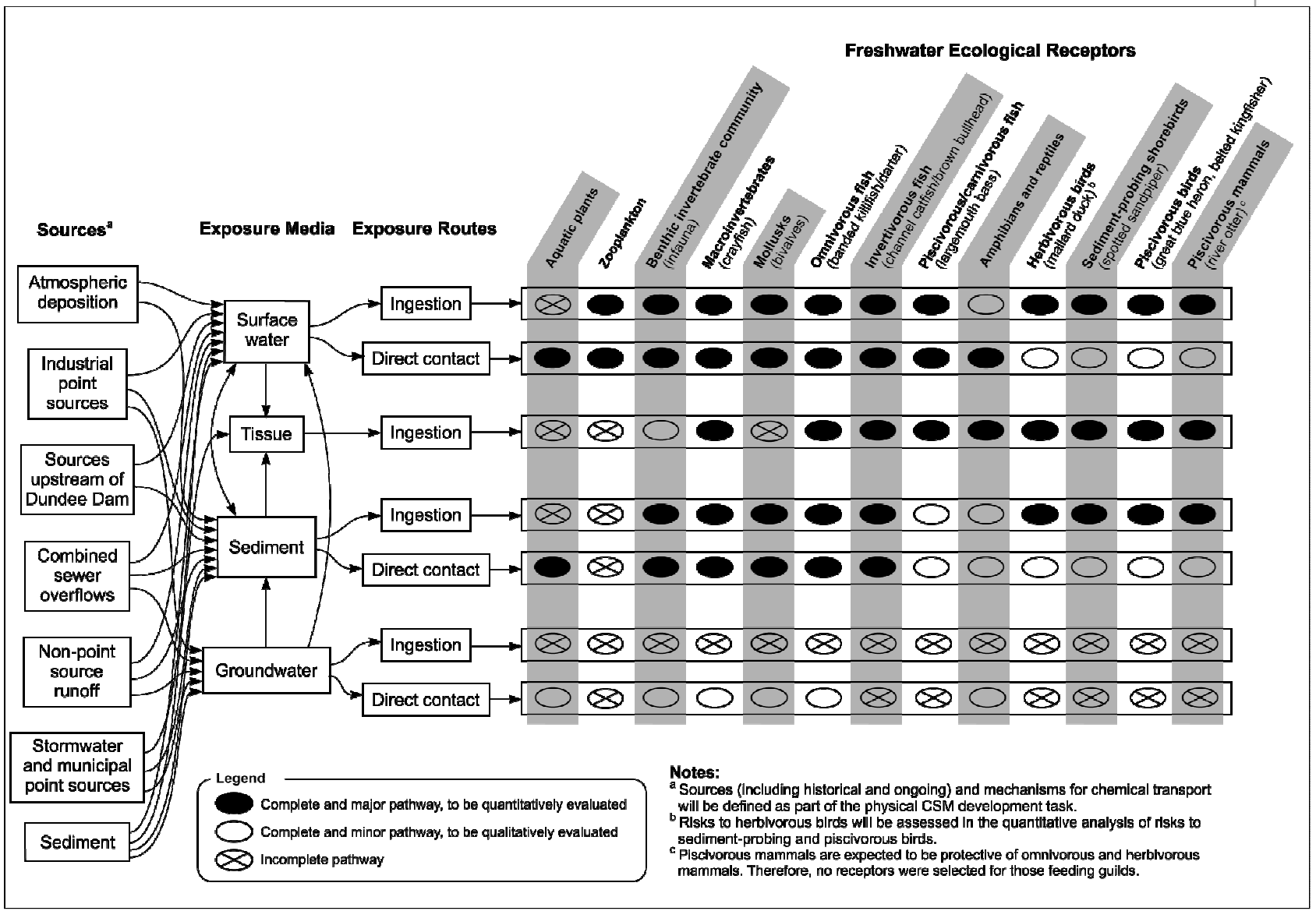

Figure 5-3. Preliminary ecological CSM for LPRSA freshwater receptors

5.2 Receptor Selection and Exposure Pathways

A systematic process, consistent with USEPA guidance, was used to select preliminary representative receptor species based on the available biological surveys and other information (e.g., habitat data) from the LPRSA and the surrounding area. Several factors were considered in the selection of ecological receptors:

- **Potential for exposure to sediment-associated chemicals at the site –** Ecological species exposed to sediments through direct and incidental ingestion of sediment, ingestion of sediment-exposed prey, or direct contact with sediments have the greatest potential for exposure to sediment-associated chemicals. In addition, ecological species with small home ranges and whose site use is limited to areas within the LPRSA have a greater potential for exposure to site-related chemicals in sediment than do migratory species, species with large home ranges, or species that do not exclusively use aquatic habitats.
- **Relative ability to bioaccumulate/biomagnify site-related chemicals –** Species from upper trophic levels (e.g., piscivores) have a greater potential for long-term exposure to bioaccumulative chemicals and a greater potential for the biomagnification of those chemicals.
- **Societal and cultural significance (including species that are highly valued by society) –** Federally threatened and endangered species have special consideration in the selection of receptors. Also, those species that are commercially and recreationally important receive greater consideration in the selection of receptors.
- **Ecological significance (including species that serve a unique ecological function) –** Species with unique foraging preferences, such as those that primarily feed in shallow mudflat areas or on the river bottom, receive special consideration.
- **Sensitivity to site-related chemicals –** Species with known sensitivities to particular chemicals (e.g., piscivorous birds and DDTs) receive special consideration in the selection of receptors.

The potential chemical exposure pathways were evaluated for all receptors to determine which pathways will be evaluated as part of the BERA. Ecological receptors may be directly exposed to chemicals through contact (e.g., direct contact of benthic organisms to sediment), through the ingestion of chemicals in water or sediments, or indirectly through the ingestion of contaminated prey. For an exposure pathway to be complete, a chemical must be able to travel from the source to ecological receptors and be taken up by the receptors via one or more exposure routes.

Potential exposure pathways were categorized into three types for the purpose of the risk evaluation:

- **Complete and major –** Exposure pathways that are complete and major are those pathways that are expected to contribute the greatest potential for exposure. All exposure pathways designated as complete and major will be evaluated quantitatively as part of the risk assessment for those receptors selected for assessment.
- **Complete and minor –** Complete and minor pathways are exposure pathways that are complete but not likely to significantly contribute to the exposure of a receptor to chemicals. These pathways will be qualitatively evaluated in the risk assessment for those receptors selected for assessment.
- **Incomplete –** Pathways are designated as incomplete when ecological receptors cannot be exposed to chemicals via a specific medium. These pathways will not be further evaluated in the risk assessment.

Table 5-1 presents receptors and potentially complete exposure pathways that were tentatively selected to be evaluated in the BERA. The list of receptors may change as additional data are collected as part of the ongoing sampling efforts and as more site-specific data become available.

Table 5-1. Selected potential ecological receptors of concern

Receptor	Estuarine Receptor	FW Receptor	Rationale	Potentially Complete and Major Exposure Pathway	Potentially Complete and Minor Exposure Pathway
Aquatic Plants					
Aquatic plants	X	X	Multiple species are represented, including submerged macrophytes but are limited because of the physical development of the shorelines and poor light penetration of the water.	direct contact with surface sediments and surface water from root uptake	direct contact with groundwater (as porewater)
Invertebrates					
Zooplankton community[a]	X	X	Multiple species are represented; zooplankton are present in the water column.	ingestion of and direct contact with surface water	
Benthic invertebrate community	X	X	Multiple infaunal species are represented.	direct contact with the biologically active zone of sediment and surface water and through the ingestion of sediment and surface water	ingestion of prey and direct contact with groundwater (as porewater)
Macroinvertebrate populations	X	X	Multiple species are represented (crab and crayfish); blue crab and crayfish represent important estuarine and freshwater predators, respectively, and are also preyed on by fish and wildlife.	direct contact with the biologically active zone of sediment and surface water and through the ingestion of sediment, surface water, and prey	direct contact with groundwater (as porewater)
Mollusk populations	X	X	Multiple bivalve species are represented (e.g., oysters and mussels).	direct contact with the biologically active zone of sediment and surface water and through the ingestion of sediment and surface water	direct contact with groundwater (as porewater)
Fish					
Benthic omnivore: mummichog	X		Mummichog are an abundant resident fish species; they have a small home range (which represents localized exposure).	direct contact with and incidental ingestion of surface sediments; ingestion of prey; ingestion of and direct contact with surface water	direct contact with groundwater (as porewater)
Benthic omnivore: banded killifish/ darter		X	Benthic feeders are in direct contact with sediments while feeding (high potential for exposure to sediment-associated chemicals); selected receptors have a long life span.	direct contact with and incidental ingestion of surface sediments; ingestion of prey; ingestion of and direct contact with surface water	direct contact with groundwater (as porewater)

Receptor	Estuarine Receptor	FW Receptor	Rationale	Potentially Complete and Major Exposure Pathway	Potentially Complete and Minor Exposure Pathway
Invertivore: white perch	X		Younger perch (up to approximately 2 years of age) were selected over other invertivorous species (e.g., winter flounder and Atlantic tomcod) because white perch have been observed in the LPRSA and have strong site fidelity and small home range (representing localized exposure); selected receptor has a long life span.	ingestion of prey; ingestion of and direct contact with surface water	direct contact with and incidental ingestion of surface sediments
Invertivore (pelagic): channel catfish/bullhead		X	Selected receptors are small freshwater residents; they have a limited home range.	direct contact with and incidental ingestion of surface sediments; ingestion of prey; ingestion of and direct contact with surface water	
Carnivore/piscivore (migratory): American eel	X		American eel were selected over other migratory piscivores (e.g., striped bass) because of their unique life history (catadromous species spawn in the Atlantic Ocean, migrate to fresh water as larvae, and remain for 5 to 20 years until they are sexually mature). There is some uncertainty associated with the wide home range of American eels and the potential for their exposure to chemicals outside the LPRSA.	Ingestion of prey; ingestion of and direct contact with surface water	direct contact with and incidental ingestion of surface sediments
Piscivore: largemouth bass		X	Largemouth bass prey primarily on fish (high potential for exposure to bioaccumulative chemicals) and have a long life span; largemouth bass have been observed in the LPRSA.	ingestion of prey; ingestion of and direct contact with surface water	direct contact with and incidental ingestion of surface sediments
Amphibians/Reptiles					
Amphibian and reptiles	X	X	Multiple species may be represented (e.g., bullfrog, snapping turtle) in the freshwater portion of the LPRSA; there is a very limited presence of amphibians and reptiles in the estuarine portion of the LPRSA.	direct contact with surface water; ingestion of prey	direct contact with and incidental ingestion of surface sediments; ingestion of surface water; direct contact with groundwater (as porewater)
Birds[b]					
Aquatic herbivore (dabbling duck): mallard duck	X	X	Mallards have been observed year-round in the lower portion of the LPRSA.[e]	ingestion of biota prey; ingestion of surface water; incidental ingestion of surface sediment	direct contact with surface water and surface sediment

Receptor	Estuarine Receptor	FW Receptor	Rationale	Potentially Complete and Major Exposure Pathway	Potentially Complete and Minor Exposure Pathway
Sediment probing invertivore: spotted sandpiper	X	X	These shorebirds are frequently observed in the lower portion of the LPRSA. They have a limited foraging range during breeding season and feed by probing in mudflat sediments (high potential for exposure to contaminated sediments in intertidal habitats).	ingestion of biota prey; incidental ingestion of surface water and surface sediment	direct contact with surface water and surface sediment
Migratory piscivore: heron/egret species	X	X	Numerous studies on the life history and sensitivity to bioaccumulative chemicals are available; herons and egrets feed almost exclusively on fish (high exposure to bioaccumulative chemicals); some species have a relatively small home range from their nesting sites during breeding season.	ingestion of biota prey; incidental ingestion of surface water and surface sediment	direct contact with surface water and surface sediment
Resident piscivore: belted kingfisher	X	X	Belted kingfisher are year-round residents in the LPRSA; their diet is almost exclusively fish. Kingfisher use the LPRSA for breeding. They were selected over herring gull because herring gull are scavengers with a highly variable diet.	ingestion of biota prey; incidental ingestion of surface water and surface sediment	direct contact with surface water and surface sediment
Mammal[d]					
Piscivore: river otter	X	X	River otter are semi-piscivorous. Their foraging range can be limited to length of LPRSA; however, potential LPRSA habitat is very limited, and otters have not been observed in LPRSA; uncertainty regarding site use of the river otter in the LPRSA is assumed to be very high.[e]	ingestion of biota prey; incidental ingestion of surface water and surface sediment	direct contact with surface water and surface sediment

[a] Zooplankton exposure to chemical concentrations in the water column (i.e., surface water) will be evaluated using the same analysis as that conducted for the benthic invertebrate community assessment.

[b] No raptor bird species was selected. The diet of raptors is not expected to be limited to the LPRSA or LPRSA contaminants.

[c] The mallard duck is not proposed to be a quantitatively evaluated receptor because the potential exposure to chemicals is expected to be higher for other higher-trophic-level avian receptors (i.e., invertivores and piscivores).

[d] The selected piscivorous mammal (i.e., river otter) is expected to be protective of herbivorous mammals (e.g., muskrat) and omnivorous mammals (e.g., raccoon). Therefore, no receptors were selected for those feeding guilds. The potential exposure to chemicals is expected to be higher for piscivorous mammals. Furthermore, the omnivorous diet of the scavenging raccoon (which includes residential garbage) is not expected to be limited to the LPRSA or LPRSA contaminants, whereas the diet of piscivorous mammals may be more limited to the LPRSA.

[e] Selection of the river otter may be overly conservative for the protection of mammals that currently use habitat along the LPRSA.

FW – fresh water
LPRSA – Lower Passaic River Study Area

5.3 Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints

USEPA (1998) defines assessment endpoints as "explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes." Accordingly, assessment endpoints should include both the ecological receptor group or species and characteristic of the ecological function to be protected. According to USEPA (1997), the selection of assessment endpoints depends on:

- Chemicals present and their concentrations
- Chemicals' mechanisms of toxicity to different groups of organisms
- Ecologically relevant receptor groups that are potentially sensitive or highly exposed to the chemical and attributes of their natural history
- Potentially complete exposure pathways

Following the selection of assessment endpoints, a testable hypothesis must be developed to determine whether or not a potential risk to the assessment endpoint exists (USEPA 1997). A testable hypothesis is an operational statement of an investigator's research assumption made in order to evaluate logical or empirical consequences (USEPA 1997, 1998). For the LPRSA BERA, the testable hypotheses are presented as a series of risk questions about the relationship between each of the assessment endpoints and the responses of the receptors when exposed to chemicals within the LPRSA.

The general risk question, **"Are COPC concentrations in various exposure media (i.e., sediment, surface water, tissue) from the LPRSA at levels that might cause adverse effects on the survival, growth, and/or reproduction of the receptors of concern?"** is used to prepare a series of testable hypotheses that apply to the assessment endpoints. Hypotheses usually postulate that there is no effect or no difference (among groups or measurements), and data are collected to confirm or refute that hypothesis. Based on the January 14-15, 2009, workshop, this document provides a series of risk questions.

Table 5-2 presents an overview of the proposed assessment endpoints, hypotheses (phrased as questions), representative receptors, measurement endpoints, data use objectives, and biological data to be collected to support the BERA. These were selected based on review of the RI data and information collected by Tierra Solutions for the lower 1 to 7 miles of the river (Tierra Solutions references are presented in Tables 3-1 through 3-4), PAR (Battelle 2005), FFS (Battelle 2007b), FSP 2 (Malcolm Pirnie et al. 2006), and the 2006 BERA workshop meeting minutes (USEPA 2006).

Also included in Table 5-2 is a general discussion of the data that may be collected and/or compiled based on existing data, as appropriate, from urban background areas to help address the risk questions and measurement endpoints. An urban regional background approach and stressor evaluation will be developed for use in the risk characterization of the risk assessments, subject to USEPA approval (USEPA 2002).

Table 5-2. Preliminary assessment endpoints, description of measurement endpoints, and data to be sampled for the LPRSA BERA

Receptor Group and Assessment Endpoint[a]	Testable Risk Question	Description of Measurement Endpoint	Data Use Objective	Biological Data/Media to be Sampled from LPRSA	Background Evaluation?[b]	Number/Seasonality of Proposed Samples
Assessment Endpoint No. 1 – Maintenance of zooplankton communities that serve as a food base for juvenile fish	Are COPC concentrations in surface water in the LPRSA at levels that might affect the maintenance of the zooplankton community as a food resource for fish?	Chemical concentrations in surface water collected from relevant exposure areas as compared with toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of zooplankton to chemicals in surface water via various exposure pathways	Surface water chemistry and conventional parameters from relevant exposure areas (e.g., water column)	None	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 2 – Protection and maintenance (i.e., survival, growth, and reproduction) of the benthic invertebrate community, both as an environmental resource in itself and as one that serves as a forage base for fish and wildlife populations	Are benthic communities different from those found in similar nearby water bodies where chemical concentrations are at regional background levels?	Community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) as compared with appropriate regional background datasets using diversity indices, multivariate, and spatial statistical techniques[c]	Assessing adverse effects of LPRSA chemicals on benthic invertebrate communities and receptors via various exposure pathways; evaluating regional background and physical/biological stressors as part of risk characterization to help make informed risk management decisions	Benthic invertebrate taxonomic survey and identification data (Specific details, including collection of both chemical and conventional parameters [e.g., salinity, TOC, grain size] will be provided in the 2009 QAPPs.)	Estuarine and freshwater urban regional background location(s) (using existing data, if appropriate).	Exact sample size and frequency TBD with USEPA
	Are COPC residues in benthic invertebrate tissues from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of infaunal invertebrates?	Chemical concentrations in laboratory-exposed benthic infaunal invertebrate tissues (*Nereis virens* in the estuarine portion and *Lumbriculus variegatus* in the freshwater portion) exposed to LPRSA sediment in 28-day bioaccumulation tests as compared with critical body residue TRVs	Assessing adverse effects of LPRSA chemicals on benthic infaunal invertebrate receptors; developing a food web model for higher organisms	Whole-body infaunal benthic invertebrate tissue from laboratory bioaccumulation testing using LPRSA surface sediment (Specific details, including collection of both chemical and conventional parameters [e.g., salinity, TOC, grain size] will be provided in the 2009 QAPPs.)	None	Exact sample size TBD with USEPA
	Are COPC concentrations in LPRSA sediments from the biologically active zone at levels that might cause an adverse effect on survival, growth, and/or reproduction of the benthic invertebrate community?	Chemical concentrations in sediment as compared with toxicity-based sediment quality values from the literature that are specific to benthic invertebrates[c]	Estimating the exposure of benthic invertebrate receptors to chemicals in sediment via various exposure pathways	Surface sediment (from the biologically active zone) chemistry and conventional parameters	None	Exact sample size TBD with USEPA
		Laboratory bioassay tests (28-day survival and growth of *Hyalella azteca* throughout the LPRSA, 10-day survival and growth of *Chironomus dilutus* in the freshwater portion, and 10-day survival of *Ampelisca abdita* in the estuarine portion) using LPRSA sediment statistically compared with biological responses to control sediment[c]	Assessing adverse effects of LPRSA chemicals in sediment on benthic invertebrate receptors via various exposure pathways; evaluating regional background and physical/biological stressors as part of risk characterization to help make informed risk management decisions	Surface sediment chemistry and conventional parameters (from the biologically active zone)	Utilizing a gradient analysis from the site and estuarine and freshwater urban regional background data (using existing data, if appropriate) to support risk management decisions.	Exact sample size and frequency TBD with USEPA
	Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of the benthic invertebrate community?	Chemical concentrations in surface water collected from relevant benthic invertebrate exposure areas as compared with toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of benthic invertebrate receptors to chemicals in surface water via various exposure pathways	Surface water chemistry and conventional parameters from relevant exposure areas (e.g., near-bottom)	None	Exact sample size and frequency TBD with USEPA

Receptor Group and Assessment Endpoint[a]	Testable Risk Question	Description of Measurement Endpoint	Data Use Objective	Biological Data/Media to be Sampled from LPRSA	Background Evaluation?[b]	Number/Seasonality of Proposed Samples
Assessment Endpoint No. 3 – Protection and maintenance (i.e., survival, growth, and reproduction) of healthy populations of blue crab and crayfish that serve as a forage base for fish and wildlife populations and as a base for sports fisheries	Are COPC residues in benthic invertebrate tissues from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of macroinvertebrate (blue crab and crayfish) populations in the LPRSA?	Chemical concentrations in site-collected benthic macroinvertebrate whole-body tissue (crab and crayfish) as compared with literature-based critical body residue TRVs	Estimating the exposure of benthic invertebrate receptors to chemicals via various exposure pathways; developing a food web model	Whole-body benthic invertebrate tissue of selected site-specific receptors (crab and crayfish)	None	Exact sample size TBD with USEPA
	Are COPC concentrations in LPRSA sediments from the biologically active zone at levels that might cause an adverse effect on survival, growth, and/or reproduction of macroinvertebrate populations?	Chemical concentrations in sediment as compared with toxicity-based sediment quality values from the literature that are specific to benthic invertebrates	Estimating the exposure of benthic invertebrate receptors to chemicals in sediment via various exposure pathways	Surface sediment (from the biologically active zone) chemistry and conventional parameters	None	Exact sample size TBD with USEPA
	Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of macroinvertebrate populations?	Chemical concentrations in surface water collected from relevant benthic invertebrate exposure areas as compared with toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of benthic invertebrate receptors to chemicals in surface water via various exposure pathways	Surface water chemistry and conventional parameters from relevant exposure areas (e.g., near-bottom)	None	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 4 – Protection and maintenance (i.e., survival, growth, and reproduction) of healthy mollusk populations	Are COPC residues in benthic invertebrate tissues from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of mollusk populations in the LPRSA?	Chemical concentrations in tissue from *in situ* caged bivalves; this measurement endpoint is being conducted per USEPA direction	Assessing adverse effects of LPRSA chemicals on bivalves; developing a food web model	Whole-body benthic invertebrate tissue of selected test bivalve species	None	Exact sample size and test methods TBD with USEPA
	Are COPC concentrations in LPRSA sediments from the biologically active zone at levels that might cause an adverse effect on survival, growth, and/or reproduction of mollusk populations?	Chemical concentrations in sediment as compared with toxicity-based sediment quality values from the literature that are specific to benthic invertebrates	Estimating the exposure of benthic invertebrate receptors to chemicals in sediment via various exposure pathways	Surface sediment (from the biologically active zone) chemistry and conventional parameters	None	Exact sample size TBD with USEPA
	Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of mollusk populations?	Chemical concentrations in surface water collected from relevant benthic invertebrate exposure areas as compared with toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of benthic invertebrate receptors to chemicals in surface water via various exposure pathways	Surface water chemistry and conventional parameters from relevant exposure areas (e.g., near-bottom)	None	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 5 – Protection and maintenance (i.e., survival, growth, and reproduction) of omnivorous, invertivorous, and piscivorous fish populations that serve as a forage base for fish and wildlife populations and of fish populations that serve as a base for sports fishery	Are COPC concentrations in fish tissue from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of populations of fish that use the LPRSA?	Chemical concentrations or toxic equivalencies measured in site-collected fish whole-body tissue (and estimated egg tissue based on egg lipid data) as compared with literature-based tissue residue TRVs	Estimating the exposure of fish receptors, and other receptors that prey upon those organisms, to chemicals via various exposure pathways; evaluating urban background and physical/biological stressors as part of risk characterization to help make informed risk management decisions	Whole-body fish tissue and egg lipid content of selected receptors[d]	Literature/existing data and whole-body fish tissue of selected receptors collected , as needed, in appropriate background locations	Exact sample size TBD with USEPA
		Prey taxonomy identified in selected LPRSA fish receptors	Defining the exposure parameters (e.g., diet, trophic level) and prey composition of fish receptors within the LPRSA; evaluating urban background and physical/biological stressors as part of risk characterization to help make informed risk management decisions	Fish stomach prey taxonomy[d]	None	Exact sample size TBD with USEPA
		Physical and biological information based on gross internal/external fish health observations; histopathology of selected fish species may also be evaluated per USEPA direction	Assisting in the interpretation of the results in terms of fish population health.	Internal/external health observations; histopathology on a subset of fish/tumors per USEPA direction	None	Exact sample size TBD with USEPA

Receptor Group and Assessment Endpoint[a]	Testable Risk Question	Description of Measurement Endpoint	Data Use Objective	Biological Data/Media to be Sampled from LPRSA	Background Evaluation?[b]	Number/Seasonality of Proposed Samples
		Literature-based information on fish trophic feeding level and habitat use of selected LPRSA fish receptors	Defining the exposure parameters (e.g., diet, trophic level) and exposure areas (e.g., habitat identification and stratification) for fish receptors within the LPRSA	None; literature search[d]	None	N/A
	Are modeled dietary exposures to COPCs from LPRSA prey at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish populations that use the LPRSA?	Receptor-specific modeled daily doses of COPCs [e] (estimated from surface sediment, surface water,[f] and prey [invertebrate and fish] tissue chemistry)as compared with literature-based dietary TRVs	Estimating the exposure of fish receptors to chemicals via the dietary exposure pathway	Surface sediment (from the biologically active zone) and surface water chemistry from relevant exposure areas and benthic invertebrate and fish prey (or representative prey) tissue[d]	None	Exact sample size TBD with USEPA
	Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish populations that use the LPRSA?	Chemical concentrations in surface water collected from relevant fish exposure areas as compared with literature-based toxicity values (i.e., aquatic thresholds)	Estimating the exposure of fish receptors to chemicals in surface water via various exposure pathways	Surface water chemistry from relevant exposure areas (e.g., near-bottom)	None	Exact sample size TBD with USEPA
	What are the egg numbers (or mass) from estuarine benthic omnivores (i.e., mummichog) from the LPRSA?	Egg counts (or mass) in selected gravid mummichog; this measurement endpoint is being conducted per USEPA direction	Assisting in the interpretation of the results in terms of fish population health.	Mummichog eggs from selected gravid females	None	Exact sample size TBD with USEPA
Assessment Endpoint No. 6 – Protection and maintenance (i.e., survival, growth, and reproduction[g]) of herbivorous, omnivorous, sediment-probing, and piscivorous bird populations	Are modeled dietary doses of COPCs based on LPRSA biota, sediment, and surface water and/or modeled piscivorous bird egg tissues based on LPRSA fish at levels that might cause an adverse effect on survival, growth, and/or reproduction of bird populations that use the LPRSA?	Receptor-specific modeled daily doses (estimated from surface water, surface sediment, and prey [invertebrate and fish] tissue chemistry) as compared with literature-based dietary TRVs; modeled piscivorous bird egg tissue residue concentrations (estimated from fish prey tissue chemistry and dietary dose/maternal transfer model) as compared with literature-based bird egg tissue residue TRVs	Estimating the exposure of bird receptors to chemicals in surface water, sediment, and prey tissue[h] via various exposure pathways; developing a food web model	Surface sediment (from the biologically active zone) and surface water chemistry from relevant exposure areas and benthic invertebrate and fish prey (or representative prey) tissue	None	Exact sample size of sediment, surface water, and prey tissue TBD with USEPA
Assessment Endpoint No. 7 – Protection and maintenance (i.e., survival, growth, and reproduction) of aquatic mammal populations	Are modeled dietary doses of COPCs based on LPRSA biota, sediment, and surface water at levels that might cause an adverse effect on survival, growth, and/or reproduction of aquatic mammal populations that use the LPRSA?	Receptor-specific modeled daily doses (estimated from surface water, surface sediment, and prey [invertebrate and fish] tissue chemistry) as compared with literature-based dietary dose TRVs	Estimating the exposure of mammal receptors to chemicals in surface water, sediment, and prey tissue via various exposure pathways; developing a food web model	Surface sediment (from the biologically active zone) and surface water chemistry from relevant exposure areas and benthic invertebrate and fish prey (or representative prey) tissue	None	Exact sample size of sediment, surface water, and prey tissue TBD with USEPA
Assessment Endpoint No. 8 – Maintenance of healthy aquatic plant populations as a food resource and habitat for fish and wildlife populations	Are COPC concentrations in surface sediment and/or surface water in the LPRSA at levels that might affect the maintenance of healthy aquatic plant populations as a food resource and habitat to fish and wildlife?	Chemical concentrations in surface water and/or sediment collected from relevant aquatic plant exposure areas as compared with toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of aquatic plants to chemicals in surface sediment and/or surface water via direct contact with chemicals in sediment and water	Surface sediment (from the biologically active zone) and surface water chemistry and conventional parameters from relevant exposure areas	None	Exact sample size and frequency TBD with USEPA
Assessment Endpoint No. 9 – Protection and maintenance (i.e., survival, growth, and reproduction) of healthy amphibian and reptile populations	Are COPC concentrations in surface water and/or surface sediment from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of amphibian and reptile populations that use the LPRSA?	Chemical concentrations in surface water and/or sediment collected from relevant amphibian and/or reptile exposure areas as compared with available toxicity-based values (i.e., aquatic thresholds)	Estimating the exposure of amphibian and reptiles to chemicals in surface sediment and/or surface water via direct contact	Surface sediment (from the biologically active zone) and surface water chemistry and conventional parameters from relevant exposure areas	None	Exact sample size and frequency TBD with USEPA

Note: CPG is aware that selected habitat/survey work has been undertaken by USACE. As a result, some of the Water Resources Development Act surveys have not been included in this table. Once the USACE habitat work is completed and reviewed, CPG will work with USEPA and PA to develop a plan for supplemental habitat/survey work that may be necessary. In addition, the bird survey work and frequency will be developed with USEPA and PA. Furthermore, though each of the above endpoints focuses on chemical exposure, additional data will be collected on conventional parameters (e.g., grain size) to help in ecosystem characterization as part of the risk characterization for risk management decisions.

[a] Assessment endpoints as presented in the PAR (Battelle 2005).

[b] The approach for establishing regional background will be developed between USEPA/PA and CPG prior to the risk assessments, per the agreement of USEPA/PA and CPG during the March/April teleconference meetings.

[c] These measurement endpoints are to be used as part of the benthic invertebrate community triad approach.

[d] Additional physical and biological information collected during the fish community surveys (e.g., internal/external health observations) will also be used in the risk assessment to assist in the interpretation of the results in terms of fish population health.

[e] For chemicals that are metabolized or otherwise regulated by fish, a tissue-residue approach is not appropriate; therefore, a dietary model will be used as a line of evidence for evaluating risks to fish from metabolized or otherwise regulated chemicals.

[f] Per USEPA request, surface water will be evaluated as part of the dietary assessment for fish.

[g] Given that few aquatic birds currently use the LPRSA for breeding because of habitat constraints, the reproduction assessment endpoint for birds will evaluate whether the current levels of chemicals would impact reproduction if suitable habitat were present under future conditions following habitat restoration.

[h] Additional biological information collected during the bird community surveys will also be used in the risk assessment to assist in the interpretation of the results in terms of avian population health.

COPC – chemical of potential concern
CPG – Cooperating Parties Group
LPRSA – Lower Passaic River Study Area
ORNL – Oak Ridge National Laboratory
PA – Partner Agencies
PAH – polycyclic aromatic hydrocarbon
PAR – pathways analysis report
QAPP – quality assurance project plan
TBD – to be determined
TOC – total organic carbon
TRV – toxicity reference value
USACE – US Army Corps of Engineers
USEPA – US Environmental Protection Agency

Further details on each receptor group and associated assessment endpoints are presented in the following sections. The exact approach for characterizing risk to each receptor, including ecosystem characterization of stressors and use of urban regional background will be presented in the Risk Analysis and Risk Characterization Plan technical memorandum.

Zooplankton Community

The zooplankton community will be evaluated as described in Assessment Endpoint No. 1 in Table 5-2: "**Maintenance of zooplankton communities that serve as a food base for juvenile fish.**"

- One risk question, presented in Table 5-2, will be evaluated to address this assessment endpoint: "**Are COPC concentrations in surface water in the LPRSA at levels that might affect the maintenance of the zooplankton community as a food resource for fish?**" This question will be addressed by comparing surface water chemical concentrations collected from relevant exposure areas with available and relevant toxicity-based values (i.e., aquatic thresholds). The data use objective for this endpoint is to estimate the exposure of zooplankton via direct contact and ingestion of chemicals in surface water. A surface water monitoring program will be developed, and the data (chemical and conventional parameters such as dissolved oxygen, salinity, pH, hardness) collected as part of that program will be used to address this risk question.

Benthic Invertebrate Community

The benthic invertebrate community will be evaluated as described in Assessment Endpoint No. 2 in Table 5-2: "**Protection and maintenance (i.e., survival, growth, and reproduction) of the benthic invertebrate community both as an environmental resource in itself and as one that serves as a forage base for fish and wildlife populations.**" Four risk questions, presented below and in Table 5-2, will be evaluated to address this assessment endpoint using five measurement endpoints, also described below.

- **Are benthic communities different from those found in similar nearby water bodies where chemical concentrations are at regional background levels?** This question will be addressed by comparing community structure data (e.g., total invertebrate abundance, species richness, and abundance of species or specific taxonomic groups) from the LPRSA to appropriate urban regional background datasets[6] using diversity indices, multivariate, and spatial statistical techniques. The data (chemicals and conventional parameters such as grain size) and analyses from the benthic community analysis will used to develop benthic community metrics, which will be used as a line of evidence. This line of evidence will be part of the sediment quality triad approach, which is a sediment assessment technique that incorporates information about sediment chemistry, toxicity, and benthic community metrics. Additional information will be collected on ecosystem characteristics such as conventional grain size, total organic carbon (TOC) and other attributes to assist in the evaluation of the data in the context of the overall health of the benthic community. The details of the approach for the sediment quality triad and risk characterization using the benthic community data will be presented in the Risk Analysis and Risk Characterization Plan technical memorandum.

- **Are COPC residues in benthic invertebrate tissues from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of infaunal invertebrates?** This question will be addressed with one measurement endpoint. Chemical concentrations in

[6] The approach for establishing regional background will be developed between USEPA/PA and CPG prior to the risk assessments and subject to USEPA approval prior to the risk assessments, per the agreement of USEPA/PA and CPG during the March/April teleconference meetings.

laboratory-exposed benthic infaunal invertebrate tissues will be compared to tissue residue TRVs. The data use objective for this measurement endpoint is to assess the adverse effects of LPRSA chemicals on the benthic invertebrate community and to use this information to develop a food web model for upper-trophic-level organisms. Because the field collection of sufficient biomass (e.g., polychaetes or oligochaetes) will not be possible in the LPRSA, laboratory bioaccumulation tests will be used to generate surrogate tissue concentration information. The test organisms will be a polychaete worm (*Nereis* virens) for the estuarine portion of the LPRSA and an oligochaete worm (*Lumbriculus variegatus*) for the freshwater portion of the LPRSA. LPRSA surface sediment will be used to conduct the 28-day bioaccumulation tests, and whole-body benthic infaunal invertebrate tissue from the tests will be chemically analyzed.

- **Are COPC concentrations in LPRSA sediments from the biologically active zone at levels that might cause an adverse effect on survival, growth, and/or reproduction of the benthic invertebrate community?** This question will be addressed with two measurement endpoints.

    - Chemical concentrations in sediment will be compared to toxicity-based sediment quality values from the literature that are specific to benthic invertebrates. The data use objective for this endpoint is to evaluate the effects of chemical concentrations in sediment on the benthic invertebrate community of the LPRSA. Surface sediment will be collected from the biologically active zone, which is estimated to be the top 6 inches, throughout the LPRSA and chemically analyzed.

    - Laboratory toxicity tests (i.e., 28-day survival and growth of *Hyalella azteca* throughout the LPRSA, 10-day survival and growth of *Chironomus dilutus* in the freshwater portion, and 10-day survival of *Ampelisca abdita* in the estuarine portions) using LPRSA surface sediment will be conducted. The data use objective for this endpoint is to assess the adverse effects of chemicals (and evaluation of conventional parameters such as grain size, TOC, sulfide, and ammonia) in sediment to the benthic invertebrate community via the various exposure pathways as defined in the ecological CSMs (Figures 5-2 and 5-3). Surface sediment for the bioassays will be collected throughout the LPRSA from the biologically active zone, which is estimated to be the top 6 inches. The results of the bioassays will be statistically compared to bioassays conducted with control sediment. The results will also be evaluated using existing urban regional background comparisons to support risk management decisions, subject to USEPA approval of an urban regional background approach. Amphipods are considered to be a sensitive biological organism for representing potential risk to the benthic community. Other toxicity test organisms (e.g., bivalve larvae) have been developed; however, they are not as reliable as a test organism (due to high variability; and difficulty in interpreting results).

- **Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of the benthic invertebrate community?** This question will be addressed comparing surface water dissolved chemical concentrations collected from relevant benthic invertebrate exposure areas to toxicity-based values (i.e., aquatic thresholds). The data use objective for this endpoint is to estimate the exposure of the benthic invertebrate community via the surface water exposure pathways as defined in the ecological CSMs (Figures 5-2 and 5-3) to chemicals in surface water. A surface water monitoring program will be developed, and the data (chemical and conventional parameters such as dissolved oxygen, salinity, pH, hardness) collected as part of that program will be used to address this risk question.

Macroinvertebrate Populations

Macroinvertebrate (blue crab and crayfish) populations will be evaluated as described in Assessment Endpoint No. 3 in Table 5-2: "**Protection and maintenance (i.e., survival, growth, and reproduction) of healthy populations of blue crab and crayfish that serve as a forage base for fish and wildlife populations and as a base for sports fisheries.**" Three risk questions, presented below and in Table 5-2, will be evaluated to address this assessment endpoint using three measurement endpoints, also described below.

- **Are COPC residues in benthic invertebrate tissues from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of macroinvertebrate (blue crab and crayfish) populations in the LPRSA?** This question will be addressed by comparing chemical concentrations of site-collected whole-body benthic macroinvertebrate tissue (crab and crayfish) to literature-based tissue-residue TRVs. Egg tissues were not proposed for chemical analysis because of the paucity of literature-based toxicity thresholds available for benthic egg tissues. Chemical concentrations in tissue residues of crab or crayfish of the LPRSA will be compared to tissue-residue TRVs for macroinvertebrates and be used to develop a food web model. Crab and crayfish will be collected throughout the LPRSA for whole-body tissue chemical analyses. Grass shrimp were not proposed for collection for tissue analysis because they are seasonally present, and the biomass of the decapod receptors selected for chemical analysis is expected to be greater.

- **Are COPC concentrations in LPRSA sediments from the biologically active zone at levels that might cause an adverse effect on survival, growth, and/or reproduction of macroinvertebrate populations?** This question will be addressed by comparing chemical concentrations in sediment to toxicity-based sediment quality values from the literature that are specific to benthic invertebrates. The data use objective for this endpoint is to evaluate the effects of chemical concentrations in sediment on macroinvertebrate populations of the LPRSA. Surface sediment will be collected from the biologically active zone, which is estimated to be the top 6 inches, throughout the LPRSA and chemically analyzed.

- **Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of macroinvertebrate populations?** This question will be addressed by comparing surface water dissolved chemical concentrations collected from relevant exposure areas to toxicity-based values (i.e., aquatic thresholds). The data use objective for this endpoint is to estimate the exposure of macroinvertebrate populations via the surface water exposure pathways as defined in the ecological CSMs (Figures 5-2 and 5-3) to chemicals in surface water. A surface water monitoring program will be developed, and the data (chemical and conventional parameters such as dissolved oxygen, salinity, pH, hardness) collected as part of that program will be used to address this risk question.

Mollusk Populations

Mollusk populations will be evaluated as described in Assessment Endpoint No. 4 in Table 5-2: "**Protection and maintenance (i.e., survival, growth, and reproduction) of healthy mollusk populations.**" Three risk questions, presented below and in Table 5-2, will be evaluated to address this assessment endpoint using three measurement endpoints, also described below.

- **Are COPC residues in benthic invertebrate tissues from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of mollusk populations in the LPRSA?** This question will be addressed with one measurement endpoint. Per USEPA, *in situ* cage bivalve tests are being planned. Chemical concentrations in tissue from *in situ* caged bivalves will be compared with tissue-residue TRVs. The data use objective for this measurement endpoint is to assess the adverse effects of LPRSA chemicals on mollusks and to use this

information to develop a food web model. This measurement endpoint is being conducted per USEPA direction. Test species and methods for *in situ* testing will be provided by USEPA.

- **Are COPC concentrations in LPRSA sediments from the biologically active zone at levels that might cause an adverse effect on survival, growth, and/or reproduction of mollusk populations?** This question will be addressed by comparing chemical concentrations in sediment to toxicity-based sediment quality values from the literature that are specific to benthic invertebrates. The data use objective for this endpoint is to evaluate the effects of chemical concentrations in sediment on mollusk populations of the LPRSA. Surface sediment will be collected from the biologically active zone, which is estimated to be the top 6 inches, throughout the LPRSA and chemically analyzed.

- **Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of mollusk populations?** This question will be addressed comparing surface water dissolved chemical concentrations collected from relevant exposure areas to toxicity-based values (i.e., aquatic thresholds). The data use objective for this endpoint is to estimate the exposure of mollusk populations via the surface water exposure pathway as defined in the ecological CSMs (Figures 5-2 and 5-3) to chemicals in surface water. A surface water monitoring program will be developed, and the data (chemical and conventional parameters such as dissolved oxygen, salinity, pH, hardness) collected as part of that program will be used to address this risk question.

Fish Populations

The fish populations will be evaluated as described in Assessment Endpoint No. 5 in Table 5-2: "**Protection and maintenance (i.e., survival, growth, and reproduction) of omnivorous, invertivorous, and piscivorous fish populations that serve as a forage base for fish and wildlife populations and of fish populations that serve as a base for sports fishery.**" Three risk questions, presented in Table 5-2, will be evaluated to address this assessment endpoint with seven measurement endpoints as described below.

- "**Are COPC concentrations in fish tissue from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of populations of fish that use the LPRSA?**" This question will be addressed with four measurement endpoints.

    - Chemical concentrations or toxic equivalencies in measured site-collected fish whole-body tissue will be compared to literature-based TRVs. Chemical concentrations in tissue residue of the fish receptors of the LPRSA will be compared to tissue residue TRVs. Fish receptors are identified for three feeding guilds: benthic omnivore, invertivore, and piscivore and will likely include species identified for the freshwater and the estuarine sections of the river (species are summarized in Table 5-1). Identified fish receptors will be collected throughout the LPRSA for whole-body chemical analyses. These data will be compared to literature-based background concentrations and/or to whole-body fish tissue chemical concentrations of selected receptors collected as needed in appropriate background locations. Background locations and the use of literature-based background concentrations will be determined and presented in the Risk Analysis and Risk Characterization Plan technical memorandum. Additional physical and biological information will be collected (details to be provided in the upcoming QAPPs) to assist in the interpretation of results in terms of fish population health. In addition, USEPA/PA and CPG agreed to include an evaluation of fish egg exposure concentrations based on lipid content. Fish egg exposure concentrations will be estimated from whole-body measurements (for lipophilic chemicals only) and egg lipid content; no chemical analyses of fish eggs will be completed. Fish egg samples will be collected from one or more

estuarine fish species and freshwater species and submitted to a laboratory only for lipid analysis. Fish egg concentrations will be compared to literature-based egg TRVs.

- Prey taxonomy will be identified in selected LPRSA receptors. The data use objective is to define the exposure parameters, such as diet and trophic level, of the fish receptors of the LPRSA and to use this information to develop a food web model for higher-trophic-level organisms. Fish stomachs will be collected during the fish tissue sampling event, and stomach contents will be analyzed only for the identification of prey organisms.

- Internal and external health observations (gross histopathological analysis) will be made on selected LPRSA fish receptors. The data use objective is to use the results in order to provide additional information in terms of fish population health. Fish health observations will be made on fish collected as part of the proposed fish community surveys. The qualitative fish health observation data (e.g., gross histopathology) will be used to provide general information about the health of LPRSA fish populations. Histopathology (e.g., of existing tumors and in liver and gonad tissues) of selected fish species may also be evaluated per USEPA direction.

- Fish trophic feeding level and habitat use of selected fish receptors will be evaluated based only on literature review (i.e., no field-collected data). The objective for this endpoint is to further define exposure parameters, such as diet and trophic feeding level, and exposure areas of fish receptors within the LPRSA.

- **"Are modeled dietary exposures to COPCs from LPRSA prey at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish populations that use the LPRSA?"** This question will be evaluated by comparing receptor-specific modeled diets associated with the ingestion of chemicals in sediment, surface water,[7] and prey tissue with literature-based dietary TRVs. The objective of this endpoint is to estimate exposure of fish receptors via exposure pathways as defined in the ecological CSMs (Figures 5-2 and 5-3) to chemicals that are metabolized or otherwise regulated by fish. This dietary model will use surface sediment chemistry (from the biologically active zone), surface water chemistry, and prey tissue chemistry, which may include benthic invertebrate and fish tissue depending on the receptor species, collected throughout the LPRSA.

- **"Are COPC concentrations in surface water from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of fish populations that use the LPRSA?"** This question will be addressed by comparing surface water concentrations collected from relevant fish exposure areas to toxicity-based values (i.e., aquatic thresholds). The data use objective for this endpoint is to estimate the exposure of the fish populations via the surface water exposure pathways as defined in the ecological CSMs (Figures 5-2 and 5-3) to chemicals (and other conventional parameters) in surface water. A surface water monitoring program will be developed, and data (chemical and conventional parameters) collected as part of that program will be used to address this risk question.

- **"What are the egg numbers (or mass) from estuarine benthic omnivores (i.e., mummichog) from the LPRSA?"** This question may be addressed by counting eggs (or estimating mass) in selected gravid LPRSA mummichog; this measurement endpoint is being conducted per USEPA direction. These data will be used in the interpretation of the results of the fish assessment in terms of fish population health.

[7] Per USEPA request, surface water will be evaluated as part of the dietary assessment for fish.

As agreed to between CPG and USEPA/PA in March/April 2009, additional measurement endpoints such as fish toxicity tests or other field-based studies (e.g., endocrine disruption) were not proposed as measurement endpoints for evaluating risks to fish.

Bird Populations

Bird populations will be evaluated as described in Assessment Endpoint No. 6 in Table 5-2: "**Protection and maintenance (i.e., survival, growth, and reproduction) of herbivorous, omnivorous, sediment-probing, and piscivorous bird populations.**"

- One risk question, presented in Table 5-2, will be evaluated to address this assessment endpoint: "**Are modeled dietary doses of COPCs based on LPRSA biota, sediment, and surface water and/or modeled piscivorous bird egg tissues based on LPRSA fish at levels that might cause an adverse effect on survival, growth, and/or reproduction of bird populations that use the LPRSA?"** This measurement endpoint will be evaluated by comparing receptor-specific modeled daily doses (and modeled bird egg tissue residues) associated with the ingestion of chemicals in surface water, sediment, and prey tissue with literature-based dietary doses (and bird egg tissue residue) TRVs. The data use objective for this endpoint is to estimate exposure of bird receptors via various exposure pathways as defined in the ecological CSMs (Figures 5-2 and 5-3) to chemicals in surface water, sediment, and prey tissue. Surface sediment chemistry (from the biologically active zone) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet, will be used to develop the dietary model for each bird receptor. Exposure data used in this measurement endpoint will be used in the development of a food web model. In addition, a surface water monitoring program will be developed, and the data collected as part of that program will be used to address this risk question.

Risks to birds may also be assessed by evaluating field-collected tissue residues of birds; however, this measurement endpoint was not selected because limited toxicity thresholds for bird tissues are available and because of the limitations associated with collecting these data in the field. General information about avian population health may also be measured using field population metrics (e.g., fledging success, egg viability[8]). This measurement endpoint was not proposed either because this is a less certain estimate of site-specific risk. However, four qualitative bird surveys will be conducted as part of the 2009-2010 data collection effort, and relevant existing avian community bird surveys (e.g., seasonal survey counts) will be used to provide general information about bird populations and the overall types of bird species utilizing the LPRSA.

Aquatic Mammal Populations

The mammal populations will be evaluated as described in Assessment Endpoint No. 7 in Table 5-2: "**Protection and maintenance (i.e., survival, growth, and reproduction) of aquatic mammal populations**."

- One risk question, presented in Table 5-2, will be evaluated to address this assessment endpoint: "**Are modeled dietary doses of COPCs based on LPRSA biota, sediment, and surface water at levels that might cause an adverse effect on survival, growth and/or reproduction of aquatic mammal populations that use the LPRSA?"** This measurement endpoint will be evaluated by comparing receptor-specific modeled daily doses associated with the ingestion of chemicals in surface water, sediment, and prey tissue with literature-based dietary dose TRVs. The data use objective for this endpoint is to estimate exposure of the aquatic mammal receptor,

[8] Spatial and temporal distributions of breeding birds were found to be constrained by habitat in the lower portion of the LPRSA (Tierra Solutions 2003).

river otter, via various exposure pathways as defined in the ecological CSMs (Figures 5-2 and 5-3) to chemicals in surface water, sediment, and prey tissue. Surface sediment chemistry (from the biologically active zone) and benthic invertebrate and/or fish prey tissue chemical concentrations, depending on receptor-specific diet, will be used to develop the dietary model for each mammal receptor. Exposure data used in this measurement endpoint will be used in the development of a food web model. In addition, a surface water monitoring program will be developed, and the data collected as part of that program will be used to address this risk question.

Per the 2006 BERA workshop meeting minutes (USEPA 2006), toxicity tests on aquatic mammals (e.g., mink) will not be performed because the need (and estimated high costs) for toxicity tests is likely not warranted. The proposed dietary modeling measurement endpoint is an appropriate estimation of risk for initial risk estimates.

Aquatic Plant Populations

Aquatic plant populations will be evaluated as described in Assessment Endpoint No. 8 in Table 5-2: "**Maintenance of healthy aquatic plant populations as a food resource and habitat for fish and wildlife populations.**" The aquatic plant populations in the LPRSA are limited due to the physical development of the shorelines and poor light penetration in the water

- One risk question, presented in Table 5-2, will be evaluated to address this assessment endpoint: **"Are COPC concentrations in surface sediment and/or surface water in the LPRSA at levels that might affect the maintenance of healthy aquatic plant populations as a food resource and habitat to fish and wildlife?"** Toxicity tests can be used as a measurement endpoint for assessing exposure and effects to plants; however, as stated in the 2006 BERA workshop meeting minutes (USEPA 2006), it is difficult to performing toxicity tests on aquatic plants, and very limited plant tissue toxicity thresholds are available from the literature. Therefore, risks to aquatic plants instead will be evaluated using screening benchmarks in sediments and surface water. The risk question for aquatic plants will be addressed comparing surface water and/or surface sediment chemical concentrations collected from relevant aquatic plant exposure areas to toxicity-based values (i.e., aquatic thresholds). The data use objective for this endpoint is to estimate the exposure of aquatic plants via direct contact with chemicals in surface sediment and/or surface water. A surface water monitoring program will be developed, and the data (chemical and conventional parameters such as dissolved oxygen, salinity, pH, hardness) collected as part of that program will be used to address this risk question. Existing data on restoration studies within the LPRSA may also be used to provide useful information about the health of LPRSA aquatic plants.

Amphibian and Reptile Populations

Amphibian and reptile populations will be evaluated as described in Assessment Endpoint No. 9 in Table 5-2: "**Protection and maintenance (i.e., survival, growth, and reproduction) of healthy amphibian and reptile populations**."

- One risk question, presented in Table 5-2, will be evaluated to address this assessment endpoint: "**Are COPC concentrations in surface water and/or surface sediment from the LPRSA at levels that might cause an adverse effect on survival, growth, and/or reproduction of amphibian and reptile populations that use the LPRSA?**" This question will be addressed by comparing surface water and/or surface sediment chemical concentrations collected from relevant amphibian and reptile exposure areas to available and relevant toxicity-based values (i.e., aquatic thresholds). The analysis of tissue residues from amphibians and reptiles is not proposed as a measurement endpoint because of the limited tissue-residue thresholds available from the literature and due to the limited occurrence of these organisms in the LPRSA. The data use objective for this endpoint is to estimate the exposure of amphibians and reptiles via direct contact

with chemicals in surface water and/or surface sediment. A surface water monitoring program will be developed and the data (chemical and conventional parameters such as dissolved oxygen, salinity, pH, hardness) collected as part of that program will be used to address this risk question.

5.4 Environmental Data Needs for Baseline ERA

Table 5-2 presents a preliminary summary of the environmental data that will be needed to estimate potential ecological exposures and assess potential adverse effects of river chemicals on ecological receptors. Information on physical and biological data from the river will also be collected to assist in data evaluation during the risk characterization. Examples of this type of additional data include information on grain size, TOC, pH, sulfides, and ammonia. The specifics will be provided in the 2009 QAPPs. Specific data will be required for the evaluation of ecological exposure:

- River and mudflat sediment (upper 6 inches/biologically active zone); chemical concentrations and conventional parameters
- River surface water; chemical concentrations and conventional parameters from relevant exposure areas (e.g., water column or near bottom, as appropriate)
- Fish whole-body (reconstituted mathematically) chemical concentrations and conventional variables and egg lipid content from the field
- Shellfish (i.e., crab and crayfish) tissue from the field; chemical concentrations and conventional parameters
- Laboratory bioaccumulation benthic invertebrate tissue from testing field collected sediment; chemical concentrations and conventional parameters
- *In situ* bioaccumulation tissue from caged bivalves (per USEPA direction)
- Laboratory toxicity tests using field collected sediment
- Benthic invertebrate taxonomic data
- Fish stomach prey taxonomy identification
- Fish community surveys
- Fish gross internal/external abnormalities (histopathology of selected fish species may also be evaluated per USEPA direction)
- Bird community survey
- Biota-sediment accumulation factors (BSAFs) for small-forage-range fish (i.e., mummichog and darter/killifish species) and invertebrates will be calculated using co-located tissue and sediment chemistry data. Methods for the calculation and use of BSAFs for the risk assessment will be described in the Risk Analysis and Risk Characterization Plan.

These environmental data needs are preliminary and subject to change as further information is obtained through the site investigation and data gathering process. Consistent with USEPA risk assessment guidance, additional studies on bioavailability or other studies to reduce uncertainty in the risk assessment and ultimately in risk management decisions for the LPRSA will be determined upon evaluation of the 2009 data.

6 Proposed Site-Specific Data Collection for 2009 and 2010

The following field program events to support the risk assessments are planned for 2009 and 2010:

- **Fish community survey and tissue collection –** The fish sampling and analysis program will be started in late summer/early fall, to coincide and be consistent with the timing of the 1999-2001 Tierra Solutions fish community survey and tissue sampling. Additional surveys are planned to capture seasonal fish community data and/or to fill data gaps.

- **Benthic invertebrate program –** This event will commence in late summer/early fall, consistent with the timing of the 1999-2001 Tierra Solutions benthic community survey and sampling. This event will likely be concurrent with the fish programs, although it is anticipated that the start date will be soon after the start of the fish program. This program will include collection of benthic community samples, as well as sediment from the biologically active zone for chemistry/conventional parameters, toxicity, and bioaccumulation testing. Additional surveys are planned to capture seasonal benthic community data and/or to fill data gaps.

- **Habitat or vegetation surveys –** The USACE recently completed the Terrestrial Vegetation Survey (USACE et al. 2008) based on methods described in FSP 2 (Malcolm Pirnie et al. 2006), including wetland delineation surveys of select locations in the LPRSA and the identification of reference locations based on wetland vegetation. Additional surveys will be considered with USEPA and the PA and may include additional vegetation or wetland surveys in areas that are identified for further evaluation based on review of the USACE 2008 survey report.

- **Bird community survey –** The first survey for birds in the LPRSA is planned, based on discussions with USEPA and the PA, to occur in 2010.

- **Human exposure review –** A human exposure review is necessary for capturing site-specific information for accurately characterizing receptors and exposures at the LPRSA, as described in Section 4.2. Data collected by the human exposure review will provide the necessary information for characterizing the types and locations of activities along the river, such as sculling, boating, swimming, children playing, homeless observations, and developing (i.e., quantifying) site-specific exposure parameters for the HHRA, such as exposure frequency.

QAPPs will be prepared for each of the above programs during calendar year 2009.

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